MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

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INDIA.

VOL. V.

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UNDER THE DIRECTION OF

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NOTICE.

The present volume of the MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA contains papers relating, as will be seen, to widely separated portions of this immense Indian Empire. The many confused, and to a large extent contradictory statements regarding the fossiliferous and other rocks of the North-Western Himalaya, will be found here reduced, by Dr. Stoliczka's exertions, to order and symmetry, each successive group taking its established place in the general series. The geological structure of Bombay on the Western Coast has been elucidated by Mr. Wynne; while carefully prepared details are also given with regard to the Coal-field of Jherria, not far from the Eastern Coast, in Mr. Hughes' report. It will thus be seen that detailed investigations of the geological structure of the country are steadily progressing in various parts of this country, all yielding results of varying but high interest and value.

CALCUTTA,
September 1866.

THOMAS OLDHAM,
Supt., Geological Survey of India.

CONTENTS.

CONTENTS.

ERRATA.

Page	39	line	15	for *tringulari*	read	*triangulari.*
„	71	„	6	„ AUTSRIACA	„	AUSTRIACA.
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„	91	„	10	„ Pl. IX., fig. 9	„	Pl. IX., fig. 1.
„	99	„	20	„ „ fig. 4	„	„ fig. 5.

CONTENTS.

LIST OF ILLUSTRATIONS, &c.

Mr. Medlicott's Sections .... *Our route (1864)* ————————

Sections now given ———————— *Jurassic ellipse* -·-·-·-·-·-

Sketch Map

SHEWING POSITION OF THE PLACES NOTICED IN THE PRESENT PAPER.

Scale 32 Miles = 1 Inch.

On transfer paper by Sobhan Buksh. LITH: BY H. M. SMITH, SURVY. GENL'S OFFICE, CALCUTTA, MAY 1865.

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Geological Sections across the HIMALAYAN MOUNTAINS, *from* WANG-TU-BRIDGE *on the River* SUTLEJ *to* SUNGDO *on the* INDUS: *with an account of the formations in* SPITI, *accompanied by a revision of all known fossils from that district, by* FERDINAND STOLICZKA, PH.D., *Geological Survey of India.*

CONTENTS.

INTRODUCTION.

Difficulties of country.

THERE are few parts of India, which offer so many difficulties to the scientific traveller, as that elevated tract of mountains which borders the North-west of British India,—the North-western Himalaya. Several portions of this country, being partly independent or protected states, have rarely, if ever, been visited by any European traveller. And such visits as have been made have usually been in great haste, for the resources of the country do not generally admit of any long stay in one place. As a result of these great difficulties, we do not as yet know much of the natural wealth of this portion of the Himalayan ranges, although probably more of this, than of the more Eastern parts of this great system of mountains.

Strachey's observations, 1851.

It was not until 1851, that the first Geological section across the Himalaya, based on actual observation and research by the able Captain (now Colonel) R. Strachey, was published.* This was a vast step, and every one inter-

* Quar. Jour. Geol. Soc. Lond. vol. VII. p. 292.

ested in Himalayan Geology must greatly regret, that the author has not since found time to make fully known to the public his investigations, which, no doubt, have been since 1851-54 considerably extended and corrected.

Other travellers.

The Geology of the Himalaya had not, however, been altogether neglected by previous travellers. The works of Moorcroft and Trebeck, of Herbert, Gerard, Jacquemont, Thomson, Cunningham and others, contain several notes of much Geological interest. Such notes, however brief they may be, will always be of high value, while they are based on unaffected and natural observations. Besides these cursory notes, I may also mention other papers treating more particularly on that portion of the North-western Himalaya, which we are about to describe more fully in the following pages,—we mean, the Spiti valley.

Gerard, 1832.

Dr. Gerard's "Observations on the Spiti valley" were published in the Asiatic Researches (Vol. XVIII pt. 2. p. 238). This paper contains only a few notes, on the last pages, regarding the occurrence of Ammonites in the Spiti valley. The author was apparently not much acquainted with Geology, and does not go much into Geological questions.

Hutton, 1841.

Captain Thomas Hutton's "Geological report on the valley of Spiti," &c., appeared in the Journal of the Asiatic Society of Bengal, 1841. p. 198. This report, so far as it is based on Capt. Hutton's own observations, and not on the authority of others, will, I think, always be found useful by any subsequent traveller along the same route. With regard, however, to his ideas or theories, we would simply quote the words of the editors of the Journal "for the views contained in this paper, the author alone is answerable." Indeed, no one who himself feels bound to progress in natural science, could be made answerable for theories such as are laid down in this paper, with an assumption of infallibility.

The Report on the valley of Spiti by Captain W. C. Hay (Journal Asiatic Society, Bengal, 1850, p. 429) contains a chapter on Geological formations (loc. cit. p. 434,) the observations in which would have been of much greater value had the author not been so positive in his identifications of the Spiti strata with known European formations. Such statements, if not at least approximately correct, are very delusive, and prevent the reader from drawing his own conclusions, which otherwise he might do from any well-observed facts if correctly stated.

Wm. Hay, 1850.

Mr. Wm. Theobald, Junr., published in 1862, "Notes on a trip from Simla to the Spiti valley," (Jour. Asiat. Soc., Bengal, 1862. p. 480). This paper does not contain any Geological notes. The author, however, mentions that they will appear with the examination of the fossils collected, at some future period, and I must state here, that I have had the valuable collections brought down in 1861, by Messrs. Theobald and Mallet, at my disposal, (with their notes on the district), and this collection added greatly to the number of fossils observed during our visit to the Spiti valley. I will have occasion several times to refer to this collection.

Theobald, 1862.

The most recently published paper on Himalayan Geology is that by Mr. H. B. Medlicott.—"On the structure and relations of the Southern portions of the Himalayan ranges between the rivers Ganges and Ravee."* This paper will, we hope, be still fresh in the memory of the readers of our memoirs; its object was to elucidate the Geological structure of the Southern portion of the North-western Himalaya, between the rivers mentioned. That which has a special interest in connection with our present purpose is the part between the plains and the Sutlej; the Geological structure of this portion of the hills is represented on the sections given by Mr. Medlicott, pp. 18, 24, and 32. These three sections give an insight into

Medlicott, 1864.

* Mem. Geol. Surv. of India Vol, III. Pt. 2.

the relations of the rocks between the plains on the South, and the Hatu Mountain near Narkanda to the North-east, of Simla. When Mr. Medlicott's report was published, the contrast between the Geological structure of the Southern portion of the Himalaya, and that of the Northern portion, so far as then known, must have been noticed by every reader. It was, therefore, of the highest interest to ascertain, if possible, the connection between these, chiefly metamorphic, rocks of the more Southern slopes, and the fossiliferous rocks of Spiti; which, since the time of Gerard's first discoveries, have been several times examined. The stratigraphical relations of these fossiliferous rocks in Spiti had not, however, been successfully traced out; and even Mr. Theobald's and Mr. Mallet's collections of 1861, gave no sufficient explanation, showing clearly a mixture of fossils from different formations. Such being the case, it was almost unavoidable to repeat the attempt to trace out the stratigraphical positions of the Spiti rocks. It is the object of this paper to give the results of this attempt.

Stoliczka and Mallet, 1864.

Charged with the reconsideration of these questions, to which I have just alluded, I proceeded with my friend and colleague on the Geological Survey, Mr. F. R. Mallet, in the beginning of June 1864, from Simla to the North-east, through Bissahir to the Spiti valley, crossing the Bhabeh Pass. The rocks in Spiti were submitted to a general examination, so far as it was possible to accomplish this during the short time of our Survey. From Spiti we proceeded across the Parang Pass to

Route.

Rupshu and so through the Para, Tsomoriri and the Puga valleys as far as the Indus. After two days march along the Indus, we turned near Ronggo, through the Hanle valley to Hanle, and returned from this by a different route to Spiti, crossing the Tagling Pass. The Western and North-western parts of Spiti were somewhat more carefully examined, and we took our way back through Lahoul and Kulu. This route

enables us to give a few sections across the country we have examined.

The small outline map (Plate I,) will be found very convenient by those who are not versed in Indian or Tibetan Geography. On this map we have not attempted to give any Geological detail, indicating nothing more than the limited extent of the Jurassic ellipse (see below). The localities of fossils have been especially marked. The position of the sections previously published by Mr. H. Medlicott is shewn by a dotted line in the South-west corner of the map: that of our own sections is also shewn, and our routes are indicated by a broken line. The sections are shown on Plate II. They begin at the Wangtu Bridge in Bissahir, and may be regarded as a continuation of the sections I have already mentioned from Mr. Medlicott's paper; and taking these together the reader will be able to obtain a general idea of the Geological structure of this portion of the North-western Himalaya.

Map.

Sections.

The rocks of the Spiti valley will be found treated with somewhat more detail, and to elucidate the stratigraphy and relations of the different formations, we would direct attention to the Section Plate II. Fig. 2, which is taken from South-east to North-west in a longitudinal direction through the valley, or in the direction of the longer diameter of the Jurassic ellipse. It would be, we think, premature to give a Geological map of the part of the North-west Himalaya, which has been examined, until the parts adjoining to the North-west and South-east have been visited. The Spiti valley is only a small portion of a large secondary basin, the extent of which to the North-west and south-east has not yet been traced out. And only when this has been done, can a correct idea be formed of the manner, in which the different formations have been deposited, and of the connection in which they stand to each other. This work is in

progress, and, we would hope, can be accomplished without any great delay.

Besides the stratigraphical and descriptive details of the Geology, we have not omitted to give those Palæontological data, which are necessary to determine the age of the different formations, a point which will be found more fully discussed at the end of this memoir. A few plates of the newly discovered fossils have been given. These fossils, however, form only a small addition to the large number already known through the researches of Messrs. H. F. Blanford,* Salter† and Oppel.‡ A general revision of all known fossils from Spiti has, therefore, been attempted, and will be found recorded at the end of the Geological notes regarding each formation separately.

Fossils.

Before entering on the Geological part of this memoir, we had better allude briefly to the Geographical position and extent of our sections. The little sketch map already alluded to will shew the general position of the district. The section given (Fig. 1 Plate II.) starts from Wangtu Bridge (across the Sutlej), about 30 miles East-north-east from Rampur, the capital of Bissahir, through the Wangur valley across the Bhabeh or Taree Pass to Sungnum at the confluence of the Para§ with the Pin river. This part of the section runs nearly due South to North. It turns at Sungnum a little to the North-east along the left bank of the Pin river, until this stream joins the Spiti river a few miles above Drangkhar.‖

Position of country visited.

* Jour. Asiat. Soc. Bengal, 1863.

† "Palæontology of Niti in the North-West Himalaya," Col. R. Strachey, Calcutta, 1865. Printed for private distribution only.

‡ Palæontologische Mittheilungen, 1864. Stuttgart.

§ *Para Kio river* on the Atlas of India Maps. Para is the name of the river. *Chu.* means flowing water, the water of a lake stationary is called *tso*; the *river* is called Para *Chu.*

‖ *Drang* means straight or vertical, and *khar* a castle; the name *Danka* as quoted by Mr. Theobald (Jour. As. Soc. Beng. 1862, p. 508) is inadmissible, and is quite unknown

The second Section (Fig. 2 Plate II.) is intended to illustrate the extension of the Jurassic basin in Spiti itself. It extends from South of the village Po on the Spiti river, over the high plateau along its left bank, passing near to or over the villages of Drangkhar, Gieumal, Hikkim,* Longja,* Tshissigaong,* Kibber, Chikkim Station, and terminates a little further to the North-west beyond the Lagudarsi† river.

The section (Fig. 3 Plate II) is taken from the left bank of the Spiti river, a few miles South-west of Kibber, over the Station at Chikkim, the Parang Pass, and along the left bank of the Para river in Rupshu; thence through the Tsomoriri and Puga valleys as far as Sungdo on the Indus river, a few miles to the West of the Mouth of the Puga Stream.

I may here remark, that the sections have been purposely selected along the road which we took, or over such places as we visited more or less closely during our trip. In a country such as this, where it would be exceedingly difficult to visit the whole extent of the mountain ranges, and where the greatest care is still necessary in fixing Geological facts, it is of essential importance not to go far from the basis of actual observation. Besides this, such sections have the additional advantages, that they can be examined by any subsequent traveller with much greater ease, than if they had been taken right across the hills in one direction, in which case it would have been nearly impossible to avoid introducing a good deal more of conjectural

to the Spiti people. They say Dangkhar, the *d* having a peculiar sound, which may be expressed in English by addition of an *r*.

* The topography of the map of the Indian Atlas here requires some correction. The village *Hikkim* is about 4 miles South of the position, it is marked at on the map on the left bank of the Shila river. The point where Hikkim is marked ought to be named *Longja;* while on the right bank of the Shila, where Longja is marked, there does not exist any village. About two miles West of this point is a little village consisting of only two houses, and called Tshissigaong.

† The inhabitants assured me, that they never heard this name for the river before, and that it is always called Tagling-chu, and the river North of the Tagling pass, Nashing-chu.

khar. OURS.

CHARACTERISTIC FOSSILS.

Orthis—?

Tentaculites, Orthis, etc.

Productus semireticulatus
Spirifer Keilhavii. etc.

Halobia Lommeli. Ammonites
floridus etc.

Megalodon triqueter and
Dicerocardium Himalayense.

Terebratula gregaria and pyriformis
Rhynconella Austriaca: Belemnites.

Trochus epulus, Chemnitzia
undulata. Terebratula sinemuriensis.

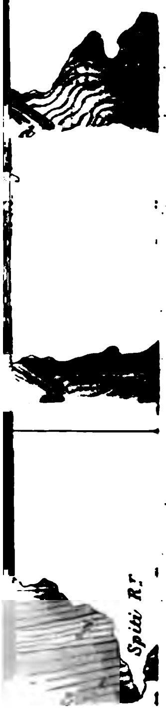
Posidonomya Ornati.

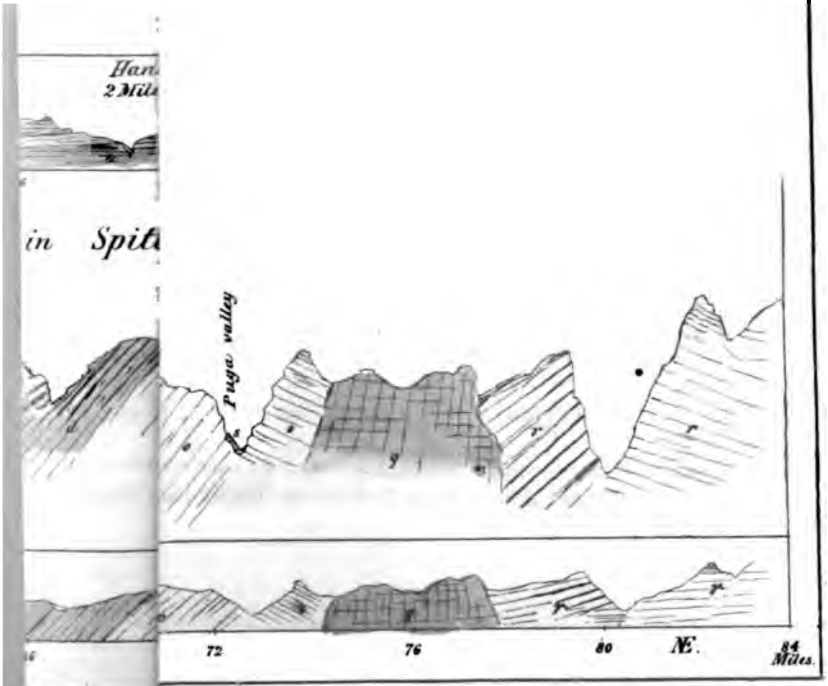
Ammonites macrocephalus; Parkinsoni;
triplicatus. etc.

Avicula echinata.

Rudista and Foraminifera.

(no fossils found).





BY H. M. SM

matter. The sections are all given on the scale of four miles equal to one inch, and have been taken from a compiled map, partly copied from the sheets of the Indian Atlas (No. 47), partly from a tracing copy of the unpublished field maps of the Southern districts of Rupshu, for the use of which we are indebted to the courtesy of Captain Montgomerie, R. E., who conducted the survey of that country. The remainder of the map was completed from Col. Cunningham's published map of Ladak, &c., enlarged for this purpose.

In order to shew the details of structure, the scale for height has been enlarged as compared with that for distance : the scale for elevations is 5,000 feet to the inch. But to avoid the erroneous idea which almost inevitably results from such distorted sections, true outlines are also given, the scales for heights and distances being the same.

Elevations.

The heights given on the Trigonometrical survey maps have been in all cases used, all intermediate heights have been calculated from observations with the boiling point Thermometer by Mr. F. R. Mallet.

PART 1. SPITI.

In describing the different formations, we shall first give a few remarks on that portion of Bissahir, which extends Northward from Mr. Medlicott's sections, namely, from Narkanda to the Wangtu Bridge. There is scarcely anything of novelty to be added here, which has not been already noticed in Mr. Medlicott's report. An account of the great mass of gneiss, which we consider as the main Geological axis of the North-Western Himalaya, will follow. And then the several formations in Spiti will be treated of in the order of their relative age, and lastly, brief notes will be given of the rocks of Rupshu. General discussions regarding the evidences for the different ages of these formations will conclude our remarks.

Description of Bisahir.

Leaving Mr. Medlicott's sections at the Hatu Mountain near Narkanda* we pass in an East-north-east direction along the left banks of the Sutlej, from the gneiss to a great variety of metamorphic rocks. These consist at first, (before reaching Kotgurh) of quartzose and somewhat chloritic mica schists. Beyond Kotgurh to the East, there are first reddish mica schists with garnets, to which succeed grey and chloritic schists (*graue* and *grüne Schiefer* of Alpine Geologists), and in the valley of the Sutlej porphyritic gneiss. At Kotgurh, the schists dip with a slight angle to the North-east, and immediately above the gneiss, for a very short distance to the South-west; the gneiss itself dipping equally on the left bank of the Sutlej to South-west, and on the right bank to North and North-east, although at only a very slight angle. The river Sutlej, therefore, here flows in a denuded anticlinal.

Porphyritic Gneiss.

The porphyritic gneiss extends along the Sutlej to near the village of Dathnagur, where it is overlaid by grey mica-schists without garnets, apparently quite identical with those East of Kotgurh. The dip, although

* Mem. Geol. Surv. of India, Vol. III, Pt. 2, p. 32.

immediately above the gneiss it is to the North-east, very soon changes to South-west, and this latter direction prevails as far as the Nagri Stream, which, at its junction with the Sutlej, flows also in an anticlinal. On this stream, the rocks are a pure white quartz-schist which, to the East, is overlaid by grey and greenish mica-schist. The white quartz-schists re-appear a short distance from Rampur, and are again followed by mica-schists. A few miles East of Rampur quartzose schists are prevalent, occasionally with some hornblendic strata.

Rampur.

These hornblendic schists pass gradually into micaceous and talcose schists, which latter are of considerable thickness, and extend round the village of Gaora. The rocks between Gaora and Sarahan are chloritic, micaceous, and talcose-schists, often with fine crystals of Garnet and of Staurotide.

Gaora and Sarahan.

At the last mentioned village (Sarahan) a thin bedded gneiss appears, soon assuming a porphyritic structure. Gneiss, either thin bedded, schistose or porphyritic, a kind of tourmaline-rock, (small crystals of schorl with quartz) and thin bedded and usually much contorted micaceous strata are the rocks between Sarahan and Tranda. From Rampur up to near this village, the dip is principally to the North-east. Before reaching Tranda specular iron is often met with in the micaceous strata, and also large masses of Biotite.

Tranda.

This mica is of a deep brown color, made up of small laminæ, which are broken and contorted in all directions, and occasionally traversed by small flakes of white Muscovite. The Biotite is very brittle, and can be easily pulverized, the Muscovite remains in its little flakes, when it has been mixed with the former. Near Tranda, the rocks dip to the West-south-west.

CHAPTER 1.—*Central Gneiss.*

To the East of the village of Tranda the rocks assume a very constant and peculiar character, which,—of course within certain limits of variation,—they retain all the way up to the Bhabeh or Taree pass. As this rock is especially well exposed at the Wangtu bridge, I shall proceed at once to describe its character at this locality, so often mentioned previously by Capt. Herbert, Capt. Hutton and other travellers.

Wangtu bridge.

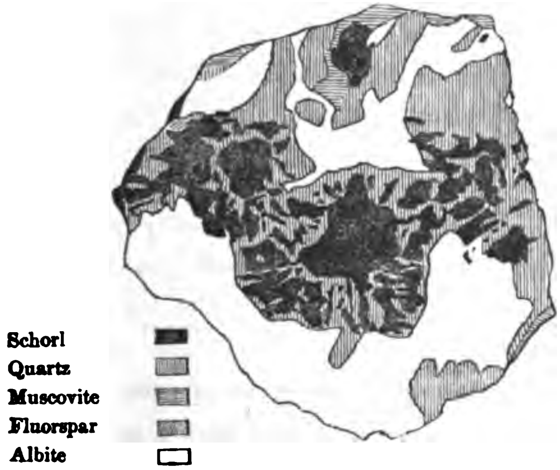
The gneiss at Wangtu has a porphyritic structure and can be generally described as granitoid gneiss. In fact as the stratification is usually in thick beds or is even obliterated, large pieces cannot be distinguished from granite. This gneiss consists of a mass of white Albite and white or greyish white Quartz in nearly equal proportions, large crystals of white Orthoclase and a considerable proportion of Biotite. This latter mineral occurs only in little laminæ, which are broken and contorted in every direction, and there is seldom a trace of Muscovite to be detected in the entire mass.* Pinkish Orthoclase is very rare here, and I noticed it only in one place near Paunda. This granitoid gneiss is traversed by a countless number of veins of Albite-granite, veins of unmeasured length, and from one to twenty feet in thickness. The principal mineral in these veins is a pure white Albite: next to it Quartz, Mica, black Tourmaline, and few other minerals. All these occur in large crystals, and the structure of the rocks is, therefore, eminently a porphyritic one. Col. R. Strachey tells me, that these veins of Albite-granite, in the neighbourhood of the Niti-pass, enter into the Silurian and even the secondary strata. There cannot be the slightest doubt as to their being of subsequent date to the gneiss, in which they are truly intrusive. This Albite-granite offers

Granitic gneiss.

* A similar structure was observed by Mr. Stur in the mica of the Central Gneiss of the Alps. Jahrb. d. K. K. Geol. Reichs-Anstalt. Vienna. 1856, vol. VII p. 407.

a rare opportunity for studying the genesis of the different minerals, and with this view I will make some observatons on an interesting specimen of which the subjoined figure is a representation reduced to half the measurements.

FIG. 1. SPECIMEN OF ALBITE-GRANITE, FROM WANGTU.



Successive formation of minerals.

Supposing the whole mass was fluid at a high temperature, the first mineral which crystallized was undoubtedly the Muscovite, which is the only Mica here as distinct from the common occurrence of Biotite in the gneiss itself. This Muscovite is often traversed and again recemented by all the following minerals and is therefore the oldest. Next to it the Tourmaline seems to have consolidated; this is always of the Schorl variety, and then the Beryl, Garnet and Fluorspar. All these minerals, although not of very common occurrence, have been found broken and cemented again by quartz, which surrounds every fragment of these minerals, so that there is no doubt as to their existence previously to the consolidation of the quartz. The Schorl is usually crystallized in six-sided prisms,* of which the shape can be easily recognized

* Three sided prisms, sometimes of a foot in length, are also not rare, especially in the Chandra valley.

in Fig. 1. These large crystals seem to have been cracked by the quartz mass to a limited depth, to which the quartz penetrated and cemented the fragments. This must, however, have been accomplished without much disturbance, and not in a very fluid mass, so that the original form of the Tourmaline crystal was retained. After the quartz consolidated and had surrounded the already formed minerals, the whole mass seems to have been cemented and filled up by the Albite, which itself comes very rarely into contact with the Tourmaline or any of the other minerals, except Quartz.

The successive ages of the different minerals can therefore be represented thus:—

1	2	3	4
MUSCOVITE.	TOURMALINE.	QUARTZ.	ALBITE.
	Beryl,		
	Fluorspar,		
	Garnet.		

The Schorl is the most prevalent of the accessory minerals. The Fluorspar is comparatively rare and generally of a light green colour; the Beryls often attain a large size up to several inches, they are white or of a light-blue colour, and very brittle. This seriously interferes with their value for ornamental purposes. The Muscovite is found in large flakes, white, grey, or oftener brown, and not uncommonly in prisms. The Albite forms sometimes nearly one-half of the whole mass, and pieces of several maunds in weight are often met with, which consist solely of this mineral.

Wangur valley.

Proceeding Northward from Wangtu, in the Wangur valley, the gneiss is found to change in character considerably in some places, and to become even schistose from the large quantity of Biotite. The dip remains constant throughout from Wangtu up to the Bhabeh pass, to North and North-east, and usually at a high angle, varying from 30° to 80°. Beyond and near Yungpa, blue Kyanite is very common in the gneiss, occurring with Garnets. I have not observed the Kyanite in the veins of the Albite granite itself, but Col. Strachey states that, at Niti, it does

occur in the veins*. The gneiss extends to the North up to a few miles South of the Bhabeh pass. It was, however, impossible to see the exact junction, as the whole country was still sheeted in snow, when we were there (23rd June).

Kunzum-pass.

Further to the North-west, we traced the boundary of the gneiss and of the overlying Silurian rocks, about six miles in a straight line, South of the Kunzum pass, on a stream North of the Shigri glacier. From here the gneiss extends to the West as far as the Hamta pass, where it is overlaid by more schistose strata. The character of the rock in this section is exactly the same as described at Wangtu, only that the appearance of stratification is usually more obliterated. The characteristic veins of Albite granite occur here also: they are more frequent in the Southern portion of the gneiss, which is also the case in the Wangtu section.

Central Gneiss.

I have described this gneiss under the title of Central Gneiss, as I believe it to be the principal Geological axis of the North-western Himalaya. I cannot say anything about its eastern or western extension, but the description seems to apply as well to those parts of Kumaon and Gurhwal, which have been examined by Col. Strachey.

Metamorphic rocks, &c.

This Central gneiss is overlaid to the North by a tolerably regular series of palæozoic and of secondary deposits. To the South follows another great series of metamorphic rocks, gneiss, mica and chloritic schists, and slates of all descriptions. The southern gneiss is often found interstratified with mica-schists, and still more frequently occupying the tops of hills or ranges of hills, being regularly underlaid by metamorphic schists or slates. This latter gneiss has, geologically speaking, nothing to do with that called above Central gneiss, although it is often very similar in structure. My experience, as to the southern flanks of the Himalaya is

* Quar. Jour. Geol. Soc. Lond. 1851, vol. VII, p. 302.

very limited, and I therefore leave this point now, hoping that a closer examination may soon enable me to discuss it more fully. The

Isolated points of Central Gneiss

occurrence of Central gneiss in isolated places South and North of the central ranges, which I have partly indicated, is of very high interest. I would point to the

at the Chor,

Chor Mountain, East of Simla, as an example of its occurrence to the South. And to the North of the central chain I have to mention the gneiss on the left bank of the Para river near Changrizing and West of Chango. This is a great

and Changrizing.

mass of gneiss, with all the characters of the Central gneiss. Occasional layers of a hornblendic or chloritic and quartzose schist give the rock locally a slightly different appearance. I am, however, unable at present to say, in what way these outlying or sporadic masses are connected with the main axis.

CHAPTER II.—*Palæozoic formations in Spiti.*

The Palæozoic rocks form the Southern and Western boundary of Spiti, and are the principal rocks in the South-eastern part of the valley. Silurian and carboniferous rocks are represented.

Before entering into a general description of the palæozoic rocks,

Two local series in each group.

I must remark, that we have to distinguish in each of the formations two local series, a Southern and an Eastern one. The first contains the deposits along the main axis of the Central gneiss; and the other, in the South-eastern portion of the Spiti valley, resting against a lateral extension of the Central gneiss extending to the North-east. The rocks in this second series are only little different, but always more highly altered than the others. There is no doubt that the two series are connected with each other a little to South-east of the Spiti valley, which part has not been surveyed yet; however, as it is unknown in

what way they are connected, I prefer to treat each separately, specially with a view to the convenience of any future examination.

§ 1.—*Silurian—Bhabeh Series.*

1. *Section South of Muth.*—In the Section (Fig. I. Pl. II.) we see the Silurian rocks overlying the gneiss at an angle of between 30° and 50°, and dipping to the North-east by north, while the strata of the gneiss dip at a much higher angle. I have already remarked, that to our great regret the climatal conditions did not allow of our seeing and examining the actual junction of the Silurian rocks with the gneiss, all being covered with snow; but the boundary, as indicated on the section, is certainly correct within the limits of half a mile.

Lowest beds.

(a). The lowest beds, which we have examined above the gneiss, were on the right bank of the Wangur river, about three miles South-east of the Bhabeh pass. They were blueish grey slates and similarly coloured sandstones. Some of the strata of the slates were silky and highly micaceous, the sandstones often greenish and more or less siliceous. All the rocks (so far as visible) on the way of the Bhabeh pass were quite the same, and they continued also for some distance on the northern side of the pass, being somewhat more than 3,000 feet thick. Not a trace of any fossil has been observed in these rocks, and in my field notes, I considered them as corresponding to those strata, which Col. Strachey mentions in Kumaon as azoic.* Although we cannot insist much on the results of so cursory an examination as ours, still the occurrence of small particles of a blueish and reddish† slate in the next beds higher in the series is certainly

Bhabeh pass.

* Quar. Jour. Geol. Soc. Lond. 1851. Vol. VII, Pl. XVII.

† We have not seen any slates of this colour *in situ*.

not opposed to the idea, that this lower series may, on future examination, be conveniently separated as distinct from the other beds.

North of Bhabeh.

(b). A few miles North of the pass, the colour of the rocks changes gradually to whitish or pinkish. The strata are partly a grey strongly siliceous sandstone, with occasional calcareous beds, and partly a white or pinkish dotted quartz rock. Blocks of the calcareous beds are often met with of a cavernous structure, the limestone having been at first changed to magnesian limestone—dolomitic limestone or dolomite—and afterwards again decomposed in part. The name 'Rauchwake' is often used for this kind of decomposed limestone. These rocks, chiefly siliceous, extend to about two miles North of the camp Balair; at this place, although generally regularly and conformably bedded, they are greatly contorted. Fossils were first noticed about five miles North of the Bhabeh pass in the siliceous and carbonaceous sandstone. They consisted of some very poor impressions of Brachiopoda, apparently an *Orthis*, but not sufficient to determine even the genus confidently.

North of Balair.

(c). Leaving Balair we come soon again upon greenish and blueish sandstones, sometimes highly micaceous, often thinly laminated, or more coarsely bedded, and occasionally with some calcareous and slaty beds interstratified. In these latter beds some impressions of Brachiopoda have also been noticed, but not in a better state of preservation than those just mentioned. This third series of beds extend to within about three miles to the South of Muth, the first village on this road to Spiti.

Next, South of Muth, the Silurian rocks are overlaid by a purple quartzite or quartzose conglomerate; both will be mentioned hereafter.

2. *Sections in East Spiti.*—I have already remarked (p. 16.) that a portion of Central gneiss appears in the most eastern part of the Spiti valley, on the left bank of the Para river. The gneiss is here overlaid by dark thin-bedded slates and sandstones. These slates dip to the North-east or nearly so towards the gneiss, although they are in some places on the banks of the Para river distinctly seen to overlie this rock. My opinion, formed on the spot, was that some denudation must have taken place further to North or North-East, and that in consequence of this all the rocks assumed a slight north-easterly dip. This is, of course, merely a supposition, requiring further investigation and proof.

East Spiti.

Near the village of Kuri I observed a great number of fossils (Brachiopoda) in the sandstone, but all these were only visible in sections on the weathered surfaces of the rock. Nothing distinct could possibly be made out; when a piece of the rock was broken off, no trace of the fossils could be noticed. Opposite Shalkhar, I often noticed in the slates Crinoid remains, which seem to belong to the rootlets of *Mariacrinus* or some allied genus. Above Shalkhar, the slates partly alternate with a greenish quartzose sandstone, and towards the top of the Kyagur pass there is a considerable thickness of blueish and whitish quartzites.

Near Kuri; Brachiopoda.

Shalkhar: Crinoids.

Following the section from the Para river to the West along the left bank of the Spiti, we see the slates, above the confluence of the two streams, overlaid by a kind of shales, which here rise up to the top of the hills, and which have a still greater thickness further on to the West. From the right bank of the Ghiu stream the road leads over quartzose schists, in part highly metamorphic. They are generally of a light grey or yellowish colour, either purely quartzose, or alternating with grey silky beds, which exhibit on the flakes a very fine parallel foliation; both are talcose and thinly bedded. The strata are

either horizontal or dip with a very slight angle to North 20° East. Further on towards the camping-ground at Hiuling the strata dip for a short distance to the West; and the whole series of these quartzose schists seems to have been therefore upheaved in the form of a dome.

Hiuling.

At Hiuling itself beds of impure yellowish limestone are not uncommon, and in proceeding to the West a darkish quartzose sandstone coarsely stratified is found to overlay them. A vast thickness of dark brown crumbling and splintery shales, alternating with greenish sandstones and light coloured quartzites succeeds, extending all the way from Hiuling up to beyond the village Po. They dip on this side of the river to North-by-east, and on the right bank chiefly to the West. We did not notice any fossils in these rocks, and as they very much resemble, in their mineralogical character, undoubted carboniferous strata, any separation from these is by no means certain.

Thabo.

At Thabo large blocks of sandstone and shale are seen, full of a *Spirifer*, but they appear to have come from above, where there are true carboniferous rocks. Both these groups of beds, however, as already stated, resemble each other much.

Beds of greenstone.

One fact induced me not to separate the whole series of rocks from Changrizing up to Po, and that is, the occurrence of beds of greenstone all through the series. This rock is either highly crystalline or a good deal decomposed, and consists of diallage and a yellowish white felspar in small particles. It occurs not in veins, but in regular beds between the other rocks, usually of no considerable thickness, from 10 to 40 feet, and it partakes of the disturbances and contortions of the other rock, as may be distinctly seen in several places along the bare sides of the Spiti river. It must, therefore, be coeval. Iron pyrites is amply disseminated through the rocks, and, by its decomposition, gives rise to the formation of gypsum, arragonite, and of several efflorescences of alum, potash, soda, &c.

Difference in sections.

The difference between this section and that across the Bhabeh pass consists chiefly in this, that the lower strata here are more altered, in a few places truly metamorphic, and that the higher beds are chiefly slaty. To trace out the connection and relation of the two to the South-east will no doubt be a very interesting task. At present we only know from Capt. Hutton's report,* that he met the first slates above the gneiss to the South of the Hangrang pass, and Dr. Thomson equally mentions limestone (? Carboniferous or Triassic) for the first time in crossing the Hangrang pass.† Mr. Theobald, in company with Mr. Mallet, visited Spiti in 1861, and they brought, from the southern foot of the Manirang pass, some chloritic schists, and from higher up dark silky slates, in which *Chætetes Yak*,‡ Salter, is very common. With this occur some other impressions, which are no doubt of organic origin, but it is not possible to say whether they belong to some kind of fucoid or to Graptolites. The slates themselves are very like those which we met below (South of) the Bhabeh pass, and remind one much of Mr. Medlicott's Simla slates.

§ II.—*Silurian (?),—Muth Series.*

Three bands.

1.—Returning to the Bhabeh section (Fig. 1, Pl. II) there will be found above the true Silurian rocks a thickness of beds of about 1,000 feet, distinguished by a different shade of blueish colour, and consisting of three separate bands. These are the rocks which we are now about to describe, and the certain age of which is left undecided.

* Jour. Asiat. Soc., Bengal. 1841, pp. 205, 206.

† Travels in the N. W. Himalaya, 1852, p. 99.

‡ Strachey's Palæontology of Niti, &c. Calcutta, 1865, p. 50.

(*a*). *Purple Rocks.* The lowest band of this series of rocks is very remarkable from its purple colour, which enables us to trace out the boundary between the lower and upper strata with much facility. At the bottom of this band is often seen a small thickness of a red quartz conglomerate in which the pieces of quartz remain white. The greater thickness moreover consists of a purple quartzitic sandstone, which sometimes alternates with thin layers of slates of the same colour. Both the conglomerate and the sandstone, near the junction with the previously described greenish sandstones, alternate with these in thin strata, although, on the large scale, the boundary is well defined. Such an alternation of a few layers cannot be regarded as of great importance at the junction of two successive series of rocks, although it is always deserving of careful notice. No trace of any kind of fossil has been noticed in these purple rocks, the total thickness of which is between 500 and 600 feet.

(*b.*) The next band is a light-coloured arenaceous limestone, in part largely siliceous. Some of the beds are purer limestone of dark colour. The total thickness ranges from 300 to 400 feet. The rock can always be easily recognized by its weathering brown on the surface, even in small fragments. Several fossils have been noticed here, but unfortunately in such a bad state of preservation, that it is impossible to come to any satisfactory conclusion as regards their age. They were—

Plants. 1.—Impressions not unlike some *Sphæro-coccites.*

Corals. 2.—*Syringopora* sp., a semi-globular large coral, composed of numerous, more or less parallel, chiefly pentagonal tubes, the width of which is usually 2 millimetres.

3.—*Cyathophyllum* sp., large species with elliptical section.

4.—*Cyathophyllum* sp., another species, resembling some younger *Placosmilia* with a much elongated, compressed section.

Echinoderms. 5.—Crinoid stems, belonging apparently to two different genera. I am not acquainted with anything like these.

Brachiopoda. 6.—*Orthis* sp., resembling *O. thakil*, var. δ. *striato-costata*, Salter:* besides these there are other fragments which could be referred to the var. *a. convexa* of the same species.

7.—*Orthis*, sp., in form and ornamentation much like *O. compta*, Salter, (*ibid*, p. 43.)

8.—*Orthis* sp., another species resembling the little *O. tibetica*, Salter, (*ibid*, p. 42.)

9.—*Strophomena* sp., the single specimen found is not unlike the Carboniferous *S. analoga*, Phillips, although the rugose undulations around the beak are less regular and recall those of *S. halo*, Salter: which may possibly be a young shell of this.

10.—*Orthis* sp., conf. *O. resupinata*, Martin, from the carboniferous series.

Annelida. 11.—*Tentaculites* sp., apparently the same as mentioned by Mr. Salter from the Silurian rocks of North of Kumaon.

(*c.*) The third band, separated in the Bhabeh section, is a white quartzite, either purely white or oftener with small brown spots, disseminated throughout. The thickness is between 200 and 300 feet. No fossils have been observed.

In justification of the heading of this series of rocks, which I left doubtful as regards its age, I must refer the reader to my conclusions. I may only mention here, that all the rocks of the Muth series lie conformably on those of the Bhabeh series.

* Strachey's Palæontology of Niti. Calcutta 1865, p. 39.

2.—In the section following up the course of the Spiti river from the East there does not anywhere exist such a strong demarcation of the Muth series, but an indication of it seems to be present, as seen on the hills above Po and above Thabo. The dark shales and slates, described above as Silurian, are followed towards the tops of the hills by four bands of rocks, of which the lowest is pinkish, the following dark brown, the next white, and the top beds are concretionary limestone — apparently, and judging from pieces of it down below, true carboniferous. This, however, is only correct so far as it was seen from the bottom of the valley, and I cannot vouch for the accuracy of the statement, as it is hardly possible to climb up those precipices, and without fossils it must remain an undecided question.

Near Po and Thabo.

§ III.—*Carboniferous,—Kuling Series.*

The white quartzite of the Muth series is, to the South of the village, overlaid in one place by a small thickness of a carbonaceous, concretionary shale, and a little farther to North-east by undoubted triassic limestone. I regret not to have observed any fossils in the concretionary shale, which is followed a little higher up by triassic limestone also. In so far I am not certain whether the *true* carboniferous rocks rise here higher up and overlie the white quarzite. However, only a very short distance North of the village the carboniferous rocks appear under the trias, and here with very characteristic fossils.

The prevalent rocks of the Kuling series are a dark brown crumbling shale and a light coloured mostly whitish quartzite, generally speaking very difficult to distinguish from the top beds of the Muth series. The total thickness is from 100 to 400 feet, but is generally not considerable. The quartzites are

Thickness.

in some places the lower beds, and in other places, as below Drangkhar, they are interstratified with the splintery shales. These latter are sometimes very micaceous or carbonaceous, and even pass into a black limestone, with fossils, which is exposed about half way between Kuling and Drangkhar in the Pin valley. To the North-west of the village Po the carboniferous rock is partly a greenish sandstone, containing *Spirifer Keilhavii*, partly a blueish concretionary limestone with *Spirifer Moosakhailensis* and some Bivalves, partly it is the common brown and splintery shale. The rocks differ locally a good deal.

Drangkhar.

Po.

The first place, where we had a good opportunity of studying the carboniferous rocks was at the village Kuling in the Pin valley. Opposite, on the right bank of the Pin, at the village Khar, the carboniferous quartzites, which are here either pinkish or white, have a thickness of about 300 feet, and are upheaved in a dome-like form. They are overlaid by carbonaceous shale and higher up by triassic limestone. From this village only a portion of the rocks extends to the other or left bank of the river, and is seen here in a remarkable position, which would lead any one into an error, if he did not carefully take record of the fossils found in the different strata. Triassic limestone, quartzite, shales, and again triassic limestone are seen apparently quite conformably over each other! It is evident that the lower triassic beds which, farther to the west, lie nearly horizontal, must, at the small stream west of Kuling, have been first upheaved, and then, by some lateral force acting from the East, again depressed. (See section p. 34). The quartzites are here chiefly white and only about 100 feet thick; they contain impressions of *Spirifer Moosakhailensis* in great number. The shales above are about 150 feet thick, and full of *Spirifer Keilhavii* and *Productus semireticulatus*. It is, however, impossible among thousands of speci-

At Kuling.

Reversed strata.

mens to obtain one, which has not suffered from lateral pressure, the effect of which has acted on all the fossils in the same direction and pressed them often perfectly flat. *Spirifer Moosakhailensis* is in these shales comparatively rare, although it does occur as well, and has been brought also by Dr. Gerard and Mr. W. Theobald.

Compressed fossils.

Following down the Pin valley a few miles to East of this locality the carboniferous rocks appear, distinctly exposed, in great distortions, the great mass of the shales below and the quartzites above. Still farther on to East in the Spiti valley proper, at the mouth of the Lingti river, North of Drangkhar, the quartzites and shales are found alternating with each other in comparatively thin beds, and higher up along the Lingti river, towards and beyond Lilang, the same are met again, below the Trias, always with the characteristic Spirifers and Producti.

North of Drangkhar.

Carboniferous rocks of this character can be traced all along the Spiti and the lateral valleys, as far as Losar, and towards the Tagling-lá and the Parang-lá on both sides. It would be of little use to enumerate all the localities, and it is sufficient to say, that they appear under the Trias, usually in dome-shaped upheavements, which I believe are only the visible portions of repeated wave-like foldings of these and probably of all the lower strata. *Spirifer Keilhavii* and *Productus semireticulatus* are the commonest and often the only fossils, which are to be met in this district.

Losar, Tagling, &c.

Fossils of the Kuling series.

The following is a list of all the carboniferous fossils, which have been observed in Spiti;

1. SPIRIFER MOOSAKHAILENSIS, *Dav.* The Spiti specimens are generally much broader, having larger wings, than those from the Punjab, but they are otherwise undistinguishable. When the fine concentric laminæ become obliterated, and also the fasciculi of ribs less distinct, it becomes very difficult to separate such specimens from the *Spir. striatus*, Martin. In truth any real distinction between the two species appears to be by no means so certain, as it might appear to be. One character is well marked in all the Spiti and the Punjab specimens, that is, the strong and sharp fold on the dorsal valve, and a corresponding sinus on the ventral valve. Neither of these appear to have been noticed so strongly expressed in any figured specimens of *Spir. striatus.* Should this character not prove essential, I confess, I am at a loss how to distinguish between the Indian and European forms; especially those which Mr. Davidson figures and describes as *Spir. striata,* Martin, *var. attenuata,* Sow. (Palæont. Soc., Lond., Foss. Brachiopoda. 1857. Vol. II., Pt. 5., p. 20, pl. II., f. 12-14.) It is certain, and indeed very remarkable that, so far as the present materials allow a conclusion, both the species—if kept separated—are quite similar in all stages of growth and exhibit the same variations.

The species has been observed in Spiti at Muth, Kuling, Po, Losar and other localities, but always scarce. It occurs abundantly in the carboniferous rocks of the Punjab.

2. SPIRIFER KEILHAVII, *Buch.* (Abhandlungen der k. Akad. Berlin, 1846, p. 74, pl. 5, fig. 2. *Spirifer Rajah,* Salter, Strachey's Pal. of the N. W. Himalaya, 1865, p. 59.) This is a very common species in the carboniferous rocks of Spiti, wherever they are met with. It agrees in all its characters so well with the species figured and described by Leopold von Buch from the Bear Island, that a separation is impossible. I am happy to state this in justification of Mr. Salter, who proposed the new name only on account of his having been assured that it occurred in Triassic beds. He never lost sight of its being a true carboniferous form, and of its being so closely allied to *Sp. Keilhavii,* that he could hardly distinguish between them.*

* See Strachey's Palæontology of Niti, &c., pp. 54, 59, 73, and note by Mr. Oldham in the Appendix p. 110.

3. SPIRIFER TIBETICUS, *Stol.* Pl. III. Figs. 1-2.

Sp. testa rhomboidalis; valvis convexis atque crassatim costatis, jugo moderate elevato, bidiviso, sinu in medio uni-costato; rostro protracto et incurvo; area magna, triangulari, deltidio bipartito; superficie minutissime punctata.

The shell is rhomboidal and the hinge line only very little longer than the greatest width of the valves, which are more or less convex. If the shell is thicker (Fig. 1), the beak is usually not so much prolonged but more incurved: the contrary takes place in a shell which is more depressed (Fig. 2). Equally with these modifications varies the size of the triangular area, the fissure of which is partly covered by a pseudo-deltidium. The mesial fold is not much elevated, consisting of two thick costæ, on each of the sides of which there are 7 or 8 simple ribs. The sinus of the ventral valve is not very deep but broad, and has in the middle a slight rib.

The surface of the shell is all over finely punctated as is characteristic for *Spiriferina.*

This species has been brought by Dr. Gerard from Spiti and is probably the same, which Mr. Salter (Strachey's Palæontology, 1865, p. 54) mentions from the Oxford collection; "wide species, with two narrow folds in front." It is of the form of *Sp. octoplicatus* and, so far as I can judge from the adherent matrix, a carboniferous fossil. I have met with only one loose specimen, which I found near Kibber. The rock adherent to it is a slate, as I know it from the carboniferous rocks only, although I am unable to vouch for its sure position.

4. SPIRIFER ALTIVAGUS, *Stol.* Pl. III. Fig. 3.

Sp. testa sub-rhomboidalis, pinguis; rostro valde prolongato atque incurvo, area triangulari; deltidio bidiviso; fissura perlonga, angusta; jugo bipartito, sinu in medio unicostato; superficie granulosa.

Shell sub-rhomboidal, being nearly as high as broad; the hinge line is a little longer than the greatest width of the shell, but its extremities are not separately extended. The beak is very much prolonged and slightly incurved. The area is large, triangular, with fine horizontal lines, divided by a long but narrow fissure, which is partly covered by a pseudo-deltidium.

Both the valves are very convex, the mesial fold is bipartite, and the sinus has in the middle one rib. Besides there are on each side 8 to 10

thinner ribs, which, in proceeding towards the periphery, curve slightly outward. The ribbings on the fold and those bounding the sinus of the ventral valve are the strongest of all. This species has been found by Dr. Gerard with the former in Spiti. It is, by the greater convexity of the valves, of which the ventral one is very much extended, and by the finer and sharper ribbing, easily distinguished from *Sp. tibeticus*, n. sp.

5. PRODUCTUS PURDONI, *Davidson.* (Quar. Jour. Geol. Soc. Lond, 1862, Vol. XVIII., p. 31, Pl. 2, f. 5.) Only a single indistinct cast has been met with at Kuling. Col. Strachey found the species at the Chorhoti pass, and it does not seem to be rare in the Punjab.

6. PRODUCTUS SEMIRETICULATUS, *Martin*, (Davidson, British Foss. Brachiopoda, vol. II., p. 149, pl. 43, figs. 1—11, and pl. 44, figs. 1—4,) occurs throughout the carboniferous shales of Spiti and farther to North-west. The specimens never attain here such great size as in the English mountain limestone, or even further to westwards in Kashmir.

7. PRODUCTUS LONGISPINUS, *Sow,* (David. l. c. p. 59 pl. 35, Figs. 5—17) has been found in a few specimens in a black carboniferous limestone about 3 miles East of the village Kuling in the Pin valley.

8. AVICULA *sp.,* from near Muth; with distinct concentric striæ of growth only and a long wing; not sufficient for description.

9. CARDIOMORPHA *sp.*, from North-west of Po; a pretty large species with broad concentric folds.

10. AVICULOPECTEN *sp.* occurs very abundantly disseminated through the carboniferous limestone North-west of Po, with *Sp. Moosakhailensis.* It is a broad, sublævigate shell of considerable thickness, but we have not been able to procure even one perfect specimen, which would show sufficiently the characters necessary for the determination of the species.

11. ORTHOCERAS (?) *sp.* Only one part of a straight concamerate shell has been found in the carboniferous quartzites at the mouth of the Pin valley: it may belong to this genus.

CHAPTER III. SECONDARY FORMATIONS IN SPITI.

§ I.—*Trias.—Lilang series.*

Above the carboniferous rocks, or the Kuling series, we meet with a vast thickness of dark-coloured rocks, chiefly limestones, of very different description as to their mineralogical characters, and belonging to different formations. The first group of these limestones, which are of Triassic age, may be called the *Lilang series*, from the village Lilang on the Lingti river, a place where these rocks can be very well studied. I may just as well remark here, that there are, to the best of my knowledge, no other beds between the carboniferous and these triassic strata in Spiti; I mean, carboniferous beds with *Spirifer Keilhavii* and *Productus semireticulatus* are immediately overlaid by beds with *Halobia Lommeli* and *Ammonites floridus*.

Lilang.

No intermediate beds.

Returning to our section (Fig. 1) across the Bhabeh pass we find, above the highest beds of the Muth series, or in places above a small thickness of the supposed Kuling series, a dark grey or black limestone, which is either compact or finely oolitic. I am unable to come to any decisive conclusion about these limestones. There can be no doubt, that the greater part of these oolites is of inorganic nature, true oolitic grains, consisting of concentric layers. On the weathered surface of the rock, however, there are sometimes forms seen, which have quite the appearance of Quinqueloculinæ, and others of Globulinæ, &c. The first triassic beds South of the village of Muth consist of that oolitic limestone with a *Spirifer* allied to *Sp. fragilis*, *Rhynchonella Salteriana*,* *Halobia Lommeli*, and a great number of Crinoid stems, which probably belong to *Encrinus Cassianus*, Lbe. (usually called *E. liliiformis*.)

Origin of structure.

* With regard to the new species the reader is referred to the Palæontological notes farther on.

Fragments of Ammonites occur occasionally, but they are more common in the interstratified beds of compact black limestone. I collected here *Am. Jollyanus*, *Khanikofi* and *Thuillieri*.

Passing a little to the North of the village of Muth we find the triassic beds above the carboniferous sandstones and shales, principally composed of little bivalves, many of which have a striking resemblance to forms known from St. Cassian, and are probably identical as *Arca impressa*, *Monotis lineata*, and others.

Pin valley.

All through the upper portion of the Pin valley, from Muth to Sungnum, the triassic limestone is seen on both sides of the river in beds, from 1 to 2 feet, greatly disturbed and contorted. Some of the principal features of the dislocations are noticed in the section. Except *Halobia Lommeli* and traces of *Brachiopoda* not many fossils occur, and even these are pretty rare. The thickness of the triassic limestone is every where at least 1,000 feet, but it exceeds in places even 2,000 feet.

Sungnum.

Near the village Sungnum, where the Pin river changes its course from North to North-east, the carboniferous beds appear in considerable thickness, as has been previously mentioned. At Kuling the triassic rocks are in a peculiar position, quite conformably seen below, and with other similar foldings, of which the explanations can be proved by directly observed facts. Besides the extraordinary compressed forms, in which the fossils occur, are not opposed to this opinion.

Above Kuling.

Ascending the low hill above the village Kuling the strata can be traced with the greatest possible clearness. We come from the quartzites with *Sp. Moosakhailensis* upon the crumbling shales with *Spir. Keilhavii* and *Prod. semireticulatus*, and above these the first layer of limestone is a bed of about 6 inches in thickness, almost solely consisting of *Halobia Lommeli*. The next beds of the limestone are very remarkable from their being

so very much like to similar beds of the upper trias in the Alps, usually called by Alpine Geologists, '*Grossoolit-Mergel*' (great oolite-marl). They are light coloured concretionary beds of limestone, impregnated with much oxide of iron. The globular structure shews with particular clearness through thin veins of the reddish oxide. The beds are from 1 to 3 feet thick, and abound with Ammonites and other fossils, but it is exceedingly rare, that a single specimen in good preservation can be obtained. This quasi-concretionary limestone is very characteristic of the lower beds of the trias in Spiti, it can almost everywhere be recognized above the carboniferous beds; its total thickness varies between 50 and 100 feet. Passing towards the top of the hill above Kuling the *Halobia Lommeli* continues to be frequent, until the beds become very earthy, thin bedded limestones, which farther to North-east are very much contorted. I have not observed any kind of fossils in these thin-bedded limestones, but they seem to be still triassic.

Concretionary limestone.

Leaving this interesting locality we come, along the left bank of the Pin river, repeatedly upon triassic limestone, resting on the Kuling series, which appears in dome-form upheavements. The limestone is chiefly compact, black, and contains occasionally *Orthoceras salinarium, Ammonites Gerardi* and *fissicostatus*, a circular *Lima* and *fragments of bones*, probably belonging to some fishes. The contortions are on both sides of the valley very great, and extend locally even into the liassic beds above, although these are not usually much affected.

Left bank of Pin river.

Exactly the same succession of the triassic beds, as has been described at Kuling, is to be found above the carboniferous rocks East of Lilang. The limestone is very rich in fossils although the *Ammonites* are mostly very indistinct in the concretionary beds. *Brachiopoda* abound and are to be had in great quantities. This locality will be very often mentioned in the

East of Lilang.

Palæontological notes; it lies about two miles East of the village Lilang on the Lingti river, and is worthy of receiving attention from any subsequent traveller. Farther to East the limestone is seen to thin out gradually, the last remnants of it are seen on the distant hills for a few miles. In North-east direction the limestone must extend much farther, of which we have no certain idea, as the country is neither accessible from the Spiti side, (at least not without very great difficulties and very considerable expense), nor was it possible to enter the Chinese province Tso-Tso from any part.

To South-east the limestone thins out equally, and in the neighbourhood of the village Thabo it is seen only occupying the very tops of the mountains.

How far it extends in the southern direction we cannot form at present any correct idea. It seems to cross the Manirang pass, and the limestone on the Hangrang pass, which Dr. Thomson mentions as being the first met on the road along the course of the Sutlej, is probably triassic. It is of no use now to offer any farther suppositions, and we leave the question for the future, when it shall receive attention.

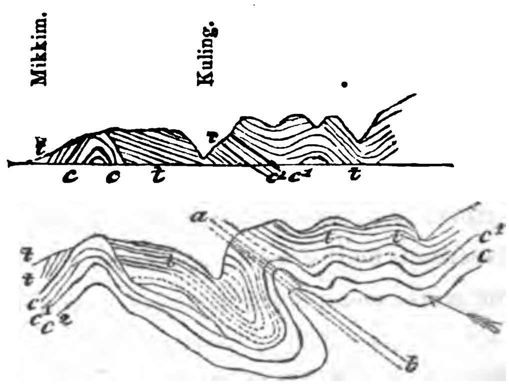
In North Spiti.

In the middle and northern portions of Spiti the triassic limestone is everywhere met with in the deep ravines and valleys, under the Tagling limestone. Along the northern declivities of the Pir-panjal range the limestones have always the same mineralogical characters, and contain the same fossils. The beds immediately above the carboniferous are nearly everywhere fossiliferous, and we could only repeat the same section from above Losar and the East of the Kunzum pass, which we have more fully described from Muth and Kuling. In the Northern part of Spiti the triassic beds are mostly compact and black, in which occasionally a *Halobia* or a fragment of an *Orthoceras* are met with. Their thickness decreases on this side of the Bara-latse range very consider-

ably, and amounts in places only to 100 or 200 feet. Contrary, however, to this the upper limestones increase very much in thickness.

The stratigraphical position of the Lilang limestones, appearing usually above the folds of the Kuling series, is nearly everywhere the same as previously mentioned. They become exposed with these in the deep valleys above the carboniferous rocks; and as all the strata contain very characteristic fossils the sections, as seen, must be explained by mechanical disturbances only. The accompanying woodcut, Fig. 2,

FIG. 2. SKETCH SECTION BETWEEN MIKKIM AND KULING.



c Carboniferous.
t Triassic.

represents the section from Mikkim to Kuling on a scale of 8 miles to an inch; it is the section, as it can be observed now on travelling along the left bank of the Para and Pin-chu. We have previously observed, that the carboniferous strata of the Kuling series consist alternately of shales or sandstones and of whitish quartzite. The upper white quartzites, which are seen East of Mikkim, must thin out farther towards the East, at least for a short distance, as indicated in the lower section. As there can be little doubt that the carboniferous rocks have been brought up by repeated wave-like foldings, we must presume the previous state of the section to have been something like the represen-

tation given. If we now let the lateral force act in the direction of the arrow, the effect would be not only a compression, but also a progression. West of Kuling a break is visible, in which a stream comes down from North-west and partly from North. The force, acting in the direction of the arrow, has caused a break along the line *a b*, and as the compressive force could not have any farther effect the progressive force could act with much greater result. In consequence of this the upper strata (shales and quartzites) have been slipped along the lower towards the West, as indicated by the dotted lines. The crushed state of the carboniferous fossils seems to be in favor of this opinion. We get in this way an explanation, how the Triassic beds (with *Am. Khanikofi*, an Ammonite similar to *Am. Johannis-Austriæ*, *Am. Thuillieri*, *Lima* conf. *Ramsaueri*, and *Halobia Lommeli*,) came below the carboniferous, which themselves show *no repetition* of the beds, as ought to be the case in a simple folding. I have preferred this somewhat lengthened explanation to one depending on breaks, repeated upheavements and denudations, because I believe it to be much nearer the truth and quite in accordance with other observed facts.

TRIASSIC FOSSILS.

The remarkable similarity and partial identity of the Himalayan Triassic fauna with that of the Alps has been already noticed by Mr. Salter in Col. Strachey's Palæontology of Niti, &c., 1865, Calcutta p. 55. Professor Suess of Vienna had also drawn attention previously to this similarity of the respective faunas. My previous studies of the Austrian fossils, and a collection which I brought to the country in 1862 aided me greatly in my determinations, and cleared up several doubts.

The following fossils belong, as has been noticed in the previous remarks, to the upper Trias only. The uniformity of the deposit and its enclosed fauna in all parts of the world is a very striking and interesting fact in the Geological history of our globe. The re-

searches of Dr. F. von Hochstetter in New Zealand,* and lately those of Mr. Whitney and F. von Richthofen in California† added greatly to our knowledge of this formation.

It was, I believe, Col. R. Strachey who, some years since, first separated the Triassic deposits in the great set of secondary limestones of the Himalayas, North of Kumaon. The descriptions of the fossils by Mr. J. W. Salter, although ready for publication in 1862, and known to many interested in the subject, have been only lately (March 1865) published. The notice of these and other fossils from different beds and of different age, gives tolerably satisfactory data for the conclusions of Col. R, Strachey. In Messrs. Schlagintweits' collection of Himalayan fossils, the descriptions of which have been partly‡ published by Professor Oppel in his "Palæontologische Mittheilungen, 1864," there exists great confusion as regard the formations to which the different species belonged. I know, from private correspondence only, that Professor Oppel suspected the different ages of the fossils but that he could not come to any certain conclusions, as Messrs Schlagintweits' information was on this point unsatisfactory. A similar admixture exists also in Dr. Gerard's collection of Spiti fossils, which have been described in the Asiatic Society's Journal, Bengal, for 1863, by Mr. H. F. Blanford.

In referring several of the following fossils, which have been previously described as jurassic, to the Trias, I can only state that these alterations may be taken as being not entirely unjustified. Of course, I must remain responsible for them, but I may be allowed to state, that I have used my best efforts to avoid any confusion. No fossils have been accepted which have not been, or at least seen to be, picked up by my colleague F. R. Mallet or by myself. Where fossils from previous collections on good authority have been described, it will be always mentioned.

* Paleontologie von Neu-Seeland, (Novara expedition) Wien, 1865. *Prof. K. Zittel* Fossile Mollusken aus Neu-Seeland, p. 19, etc.

† Sillim. Am. Journ. 1864.

‡ Prof. Oppel having received notice of the present report of my survey, has kindly informed me, that he will stop his further publication of the descriptions of the Himalayan fossils, until my memoir will appear.

The known triassic fauna of Spiti, is referrible to the following groups:

Echinodermata: crinoid stems, only.

Brachiopoda: 12 species.

Pelecypoda: 4 species.

Gastropoda: 3 species.

Cephalopoda: 18 species.

Vertebrata: Reptilian or Fish remains? (traces only).

Among 38 species of fossils we find 15 identical with those from the Alpine Trias.

I.—*Echinodermata.*

Only fragments of CRINOID STEMS have been as yet noticed at *Kuling, Muth, Lilang* and other localities. They seem to belong chiefly to *Encrinus cassianus* Laube, (Verhandlungen der k. k. geol. Reichsanstalt, Wien, 1864, vol. XIV., p. 207), a species which is very common at St. Cassian and other places in the Alps, and which has been for many years mistaken for the Muschelkalk-species *E. liliiformis,* Schlotheim. Mr. K. Laube's researches of last year have clearly shown the error of the universally accepted opinion.

II.—*Brachiopoda.*

Several of the Brachiopoda are described as new species, a few are left undetermined and referred to the nearest allied species. Of species identical with those from Europe only four are yet known, namely, *Athyris Strohmeyeri* and *Deslongchampsi, Rhynchonella retrocita* and *Rhyn. Salteriana,* n. sp. By far the majority of the specimens has been collected at Lilang on the Lingti river, North-east from Drangkhar.

1. SPIRIFER *n. sp.* A few miles west of Kuling, in the Pin valley, two specimens of a large-ribbed *Spirifer* have been found in the oolitic limestone. The species resembles much the carboniferous *Spirifer striatus.* The ventral valve has a deep sinus, and a very large triangular area, projecting nearly at a right angle from the hinge line; the deltidium is in two pieces, the fissure long, but narrow. The fold of the dorsal valve is on its greatest convexity distinctly double; this division, however, becomes obliterated towards the periphery.

Both our specimens of this, no doubt very interesting and probably new species, are insufficient to admit of its being named and described in greater detail.

2. SPIRIFER (SPIRIFERINA) *conf.* FRAGILIS, Schloth. (*Vide Alberti,* Uberblick über die Trias, 1864, p. 157).

Some imperfect specimens, but very like the Muschelkalk species, have been met with South of the village Muth, in the Pin valley. They differ only in having 7 to 9 ribs on each side of the fold, instead of the usual number of 6.

3. SPIRIFER (SPIRIFERINA) STRACHEYI, Salter. (1865 in Strach. Pal., p. 72, pl. 9, fig. 13)

The species occurs plentifully at Lilang: our specimens have usually a much longer hinge line, than is seen in Mr. Salter's figure, and are not so high. The number of ribbings on each side of the sinus varies from 5 to 8. The fold is sometimes very strong, and the dorsal valve very convex; however, among these variable forms, we possess others, which perfectly agree with the description and figures quoted above. The surface of the shell, when well preserved, is finely punctated, as is characteristic for the subgenus *Spiriferina,* d' Orb.

Col. Strachey found the first described specimens near the Rajhoti pass, North of Kumaon.

4. SPIRIFER (SPIRIFERINA) LILANGENSIS, Stol., Pl. III. fig. 4.

Sp. testa pinguis, transversaliter ovata, non auriculata, latior quam alta. Valvis convexis, plicosis: plicis simplicibus; jugo parum elevato, lato; valvæ ventralis sinu profundo; rostro valde prominente, parum incurvato; area triangulari; deltidio diviso; superficie inæqualiter granulosa.

The oval shape distinguishes this species readily from the former, the hinge line being less than the greatest width of the shell. Both valves are strongly convex; fold and sinus are simple; the former somewhat flattened, the latter comparatively deeper. On each side of the sinus are 6 to 8 ribs, simple and decreasing in strength towards the hinge line. Beak rather extended, the area projecting in nearly perpendicular direction from the dorsal valve, being accordingly

slightly concave to the beak; deltidium in two parts; fissure triangular, proportionately not very broad. The surface of the shell is distinctly granulated, the granulæ being unequal in size among themselves, and stronger than those of *Sp. Stracheyi.* Of transverse or concentric striæ of growth only a few are seen, and these at considerable distances from each other.

Locality: Lilang on the Lingti river; two specimens have been examined.

In form, but less in its ornamentation, the Spiti fossil resembles *Sp. Emerichi,* Suess, (Denksch. d. k. Akad. Wien, 1854, vol. VII., pt. II., p. 52, pl. 2, fig. 7) from the Kössner strata of the Alps.

5. SPIRIFER SPITIENSIS, Stol., Pl. III, fig. 5.

Sp. testa late-ovalis; valvis moderate convexis, costulis radiantibus, numerosis, ornatis; jugo vix elevato, parum protracto; rostro valde incurvo; fissura tringulari.

The form of the shell is broadly ovate or roundish rhomboidal, nearly quite as broad as it is high. The valves are moderately and nearly equally convex, covered with numerous radiating costulæ; the sinus and fold being very slightly marked. The ribs on the fold do not seem to be stronger than those on the rest of the shell. The hinge line is much shorter than the greatest width of the valves, and the beak is strongly prominent and incurved. The fissure is triangular, being partly covered by the umbo; the deltidial plates are not visible, they must, however, be very small; the ridges on the beak are not at all developed and the false area is scarcely marked.

Locality: Lilang on the Lingti river.

Besides the figured specimen we possess from the same locality another one, which is far more inflated, and the area, although of small size, is still distinctly marked. The beak is not so much incurved and approached to the umbo. The form, ribbing and the slightly expressed fold and sinus are identical. We merely intend by this remark to invite the attention of any subsequent traveller; the species, as indicated, may prove a distinct one, or it may be identical with *Sp. Oldhami,* Salter (in Strachey's Palæont., p. 72, pl. 9, fig. 12) from the same beds North of Kumaon; this latter species not having been observed as yet in Spiti.

6. RHYNCHONELLA MUTABILIS, *Stol.*, Pl. III. figs. 6-9.

Rh. testa ovate-rhomboidea, inflata seu depressa, variabilis atque nonnumquam deformis, radiatim costata: costis simplicibus, crassis acutisque, ad peripheriam multum fortioribus earumque terminationibus acute sinuatis. Jugo valde elevato atque prominente, 2.-*seu* 3.-*costato; rostro elongato, prope recto; apice incurvo.*

Shell sub-rhomboidal, ovate, either much inflated or somewhat depressed. It varies as well with regard to form as to its ornamentation, which consists of a few sharp ribs, disappearing towards the middle of the valves, but forming strong sinuosities at the periphery. The mesial fold is either very high, prominent, or in other cases scarcely elevated; it bears two or three (seldom four) ribs, which correspond respectively to one or two in the sinus. On each side of the fold there are two or three additional ribs, becoming considerably thinner towards the hinge line; in very few cases even a fourth lateral rib is marked. The rest of the shell surface is smooth.

The beak is sharply pointed, not very prominent or incurved, and on its ridges rounded. Foramen and deltidial plates are not clearly visible in any of our specimens, but the latter must certainly be very small. The figures 6-9 on Plate III, and the accompanying explanations, will give a better idea of the numerous variations, than it is possible to express in many words.

Of triassic allies it would be worth while to compare with our species *Ter. Johannis-Austriæ* (Klipstein, Oestl. Alpen, p. 211), and *Ter. semiplecta, Münster.* The descriptions and figures of neither give sufficient detail for comparison. Farther, the great resemblance of our species with the liassic *Rh. variabilis,* Schloth. *sp.* will, no doubt, be readily noticed, and as the amount of variation is in both very nearly the same, it is not easy to distinguish them at the first glance.

The far greater development of the area however, the sharp lateral ridges on the beak, and, in accordance with both, the large size of the deltidium, will help to recognize the liassic from the triassic species.

Locality: Lilang on the Lingti river; not rare.

7. RHYNCHONELLA THEOBALDIANA, Stol., Pl. III., fig. 10.

Rh. testa ovalis, trigona, lævigata, subinflata; sinu profundo atque lato; jugo vix elevato, ad peripheriam undulato, rostro incurvo, umboni valvæ minoris approximato.

This fine species has an ovate trigonal shape; the dorsal valve is somewhat more convex than the ventral, which has a very broad and deep sinus; the mesial fold on the former being, however, scarcely elevated above the convexity, flat, with three undulations at the periphery. From the fold the sides slope down rapidly, exhibiting each only one furrow and being prolonged as sharp prominent ridges beyond the convexity of the rostral valve. The beak is strongly bent upwards and closely impressed on the umbo. The foramen is elongated, lineal, but the deltidial plates are not visible.

The species bears some resemblance to *Ter. subacuta,* described by Count Münster from the triassic beds of St. Cassian (*vide* Münster's Beitræge, 1841, p. 55, pl. 6, fig 1.

Locality. The single specimen was found in 1861, at Muth in the Pin valley, by W. Theobald, Esq., Jun., of the Geological Survey of India.

8. RHYNCHONELLA SALTERIANA, *Stol.,* Pl. III, fig. 11-12.

Rh. testa sub-triangularis, inflata; valvis multice radiatim costatis; jugo parum elevato, lato, costulis septem ornato atque utrinque sulco profundo marginato; area magna; rostro prominente, umbone obtuso.

An ovate triangular and rather inflated shell, which is ornamented with numerous radiating ribs. Mesial fold is not much elevated, broad, bounded on each side with a deeper furrow and ornamented with seven straight ribbings. On each side of the fold there are about five additional ribs, which, in proceeding towards the periphery, slightly curve outward. The beak is rather prominent and incurved; its ridges are strongly developed, as well as those of the umbo of the dorsal valve and both together limit a flat and smooth elliptical area on each side, the median line of which shews usually slight undulations equally as the rest of the periphery of the valves. The umbo is obtuse.

The above description is derived principally from the figured specimen, which is the most perfect, and was found with all the other

species at Lilang on the Lingti river. This specimen and a few others, met with at *Muth* and *Kuling* in the Pin valley, resemble a good deal that species which has been determined by Professor Suess as *Rhyn. retrocita*, (*Vide* Salter in Strachey's Palæont. 1865, p. 71, pl. 9, fig. 11.) We possess another specimen which we rather believe to be much nearer to the true Alpine *Rhynchonella retrocita*. It would be impossible to admit the variations of this Rhynchonella to go so far, as to refer such essentially different forms to one species. There could hardly be quoted a single point of coincidence between them. There must be some mistake on this point. I have brought, from an excursion in the neighbourhood of Hallstadt in 1860, a few specimens of this Rhynchonella, and give a figure Fig. (12) of one of the specimens. They look very much like the white fossils from the Hierlatz beds on the Schafberg. However, as I have never visited this locality myself, I believe I must have got them somewhere near Hallstadt or Aussee in the triassic limestone. I cannot distinguish these Alpine specimens from ours. The species is allied to Professor Oppel's *Rh. rimata* (Zeitsch. d. Deutsch. Geol. Gesellsch, Vol. XIII, p. 542., pl. 12., fig. 2) from the Alpine Hierlatz-Schichten.

9. RHYNCHONELLA RETROCITA, (*Suess*,) *var.* ANGUSTA, *Stol.* Pl. III, fig. 13.

Rh. testa ovalis, sublævigata, valva dorsalis in medio ad peripheriam profunde sinuosa; valvæ ventralis jugo elevato; superficie radiatim minutissime striata; rostro parum prominente, deltidio diviso, foramine lineari.

Shell ovate, higher than broad; valves slightly convex, the surface covered with fine radiating striæ, which are visible on the cast. The beak is not very prominent, with distinct ridges bordering a very small and somewhat concave area on each side; deltidial plates not distinct. The point of the beak is not preserved on our specimen.

The dorsal valve is in the middle of its posterior extremity deeply indented towards the rostral valve, the greatest convexity of which runs along the medial line from the beak to the periphery. From this convexity the shell slopes down gradually to the lateral margins, an essential character of the original *Rh. retrocita*, Suess,

(*Vide* Denksch. d. k. Akademie, Wien, 1855, Vol. IX., pt. II., p. 29, pl. 1, fig. 10) from the Alpine upper Trias.

I hesitated long whether to identify our Himalayan form with the European, or to name it newly. As, however, I am well aware of the many variations of *Rhyn. retrocita*, and as the principal difference of our (single) specimen lies only in the oval form, it is no doubt preferable to regard it as a variety only. Further researches may possibly bring more material to our knowledge. The fine striæ, which are seen in our specimen, are not of much consequence. I do not exactly remember them in the European form, but I believe they do exist also on the casts. The prolongation of the mesial fold in our specimen is different from that of the Alpine originals, in which it is usually much more reflected and not prolonged at all. I have not been able to trace out the meaning of Fig. 9. on Plate 9 in Col. Strachey's Palæontology; the figure is very like our specimen, and may not Prof. Suess have intended this rather as identical with his *Rh. retrocita?*

Locality: Lilang on the Lingti river; a single specimen as yet found.

10. ATHYRIS STROHMEYERI, *Suess, sp.*

Spirigera id. 1855. Denksch. d. k. Akad. Wien, Vol. IX., pt. II, p. 27, pl. 1, figs. 4-6.—1865, Salter in Strachey's Palæont., p. 70, pl. 9, fig 10.

Several very characteristic, inflated specimens have been met with at *Lilang*. As Mr. Salter has already remarked, the Himalayan forms are found often to be broader than figured by Suess; deformed specimens are also frequently met with, and these must have possessed that shape originally, not in consequence of mechanical pressure only. The species is not rare in other localities in Spiti, as near Drangkhar, Kuling, Khar, &c. Col. Strachey found his specimens near the Rajhoti pass, and the species is also very common in the Alpine limestone of the Hallstadt-strata.

11. ATHYRIS DESLONGCHAMPSI, *Suess, sp.*

Spirigera id. 1855, Denksch. d. k. Akad. Wien, vol. IX., pt. II., p. 26, pl. 1, fig. 3.

A single specimen has been met with at Lilang on the Lingti river, but it is very characteristic. On one side, where the shell surface is weathered off, the spirals are visible; they lie so, that their

apex is directed towards the angles formed by the sides and the posterior periphery of the valves, while the axis of the spirals of the former species is perpendicular to the width of the shell.

The species occurs in the North of Kumaon also, and accompanies the former there, as in the Alps.

12. WALDHEIMIA STOPPANII, *Suess.* 1860, Palæont. Lomb. 1 ser., p. 106, pl. 23, fig. 12-16.—Salter, in Strachey's Palæont, p. 71, pl. 9, fig 6-7.

The Himalayan specimens are nearly always less inflated than the European fossil from the Esino limestone. The mesial fold is distinctly developed only in the largest of our specimens, those equal in size to Prof. Suess' figure have the fold or sinus hardly marked at all. Most of our specimens are also somewhat more oblong. The other characters agree perfectly.

The species occurs plentifully in the Lilang limestone, and has been also found by Col. Strachey on the Rajhoti pass North of Kumaon.

III. *Pelecypoda.*

Not many species of this family have been yet found, and the few which occurred are not in a very satisfactory state of preservation. A little North of the village Muth in the Pin valley and near Kuling, thin beds of limestone occur, nearly exclusively composed of little bivalves, among which several have a striking resemblance to those known from the St. Cassian beds. *Arca impressa, Monotis lineata*, several of the ribbed *Aviculæ, Nuculæ, Carditæ*, and others seem to be represented. I am sorry that there was, during our survey, not sufficient time to devote more attention to these little fossils, and I can only bring them to general notice. There would not be much gained by quoting many names and leaving them uncertain. Of special interest will be found only the following:—

1. HALOBIA LOMMELI, *Wissm.*

Hörnes, in Denksch. d. k. Akad. Wien 1855, vol. IX., pt. II., p. 52, pl. 2, fig. 17.—*Posidonomia* id, *Stoppani*, Palæont. Lombard. 1860, p. 98, pl. 19, fig. 6 (7-11 ?)—*Halobia* id, *Zittel*, Palæont. von Neu-Seeland, Wien, p. 27, pl. 4, fig. 2—*Monotis* id, *Salter* in Strachey's Palæont. 1865, p. 68, pl. 9, fig. 1-2.

The Himalayan form is exactly the same as the Alpine, and does not show even such small variations as has been noticed in the

specimens from New Zealand and California. Beds up to 6 inches thick, nearly exclusively composed of this interesting species, occur at many places in Spiti. In quite similar beds it has been noticed farther to the east by Col. Strachey, and the same strata are well known to Alpine Geologists in Europe (at Bleiberg, Hallstadt,* Aussee, Ischel, etc.). I was rather surprised not to find even a trace of the usual associate of this species, the *Monotis salinaria*, Bronn; perhaps some subsequent traveller may be more fortunate!

2. LIMA *conf.* RAMSAUERI, *Hörnes.*

1855. Denksch. d. k. Akad. Wein, vol. IX, pt. II, p. 52, pl. 2, fig. 19.

We possess only one specimen, which measures 120 mm. in width and nearly as much in height, the thickness is 71 mm. This size exceeds greatly that of the usual Alpine forms, but there are hardly any other differences to be noticed. The form of the shell, the radiating and concentric striæ, the cordial shape of the lunula, which is hollowed out, agree perfectly with Dr. Hörnes' description and figure.

From Kuling in the Pin valley.

3. LIMA *n. sp.* Shell very thick, much higher than broad, rather depressed, with striæ of growth only. One specimen has been found at Lilang; it does not agree with any known species that I am acquainted with.

Another more circular *Lima* has been noticed East of Kuling, it does not shew any particular resemblance to known Triassic species, but its nearest ally is the liassic *L. scrobiculata*, Stol. 1861, in Sitzungsb. d. k. Akad. Wien, vol. XLIII., p. 199, pl. 7, fig. 10.

4. MYOCONCHA LOMBARDICA, *Hauer.*

1857. Sitzungsb. d. k. Akad. Wien, vol. XXIV., p. 559, pl. 6, fig. 1-6).

The specimens found at Kuling agree well with F. von Hauer's description and figures, especially with Fig. 4. loc. cit. The resemblance of the fossil to *Mytilus Esinensis*, Stoppani (1860, Pal. Lomb. p. 90, pl. 18, figs. 12-13) from the upper Trias of the Southern Alps, is well worthy of notice.

* The designation of the Alpine localities by Mr. Salter in Strachey's Palæontology is not always very correct.

IV. *Gastropoda.*

With the little bivalves previously noticed, there often occur also numerous *Gastropoda* of small size. I found at *Kuling* a fragment of a large *Chemnitzia*, one of the species, of which many are known from the Southern Alps, (Esino-limestone and dolomite.) At Lilang great numbers of the similar small *Turritellæ*, *Trochi* and others, figured by Münster and Klipstein, have been met with, but they are usually visible on the weathered surface only, while hardly a trace is to be noticed of them in the rock itself. I will mention for the present merely the following species:—

1. DISCOHELIX *sp.*

Only one fragmentary specimen has been met with at *Lilang*, but it distinctly belongs to this genus, (not to *Platystoma*, Hörnes.) The shell is smooth, quite symmetrical, resembling the Liassic *Dis. excavatus* (vide *Stoliczka* in Sitzungsb. Akad. Wein, 1860, vol. XLIII., p. 194, pl. 3, figs. 1, 2); the whorls are still more numerous and narrower. So far as I am aware this is the first notice of the genus Discohelix in triassic rocks. I have a few years back, described, in the paper quoted above, several species from the Alpine Lias, and also referred to the occurrence of many species in the Lias and Jura of Normandy.

2. PLEUROTOMARIA *conf.* BUCHI, *Deslongch.* Sitzungs. d. k. Akad. Wein, Vol. XLIII., p. 188, pl. 4, figs. 4, 5.

In alluding to the liassic species, which is well known to me from the Hierlatz-strata of the Austrian Alps, I do not at present intend more, than to recall the remarkable similarity of the triassic Himalayan fossil with the former. I found it myself on two localities in the triassic beds South of *Drangkhar* and East of *Lilang*. There is no mistake about the age of the rock; notwithstanding I confess, that I am unable to distinguish the two specimens (they are not quite perfect) from the species above referred to. Farther searches will probably clear up the doubt.

3. PLEUROTOMARIA STERILIS, *Stol.* Pl. IV., fig. 1.

Pl. testa depresso-conica, trochiformis; anfractibus paucis, convexis, ad medium sub-angulatis, spiraliter atque transversaliter striatis; fascia

sinûs angusta, infra medium anfractuum sita, utrinque lineis impressis marginata; *ultimo anfractu ad basim subrotundato; basi subplana, vix striata; umbilico magno profundoque; apertura rotundate-rhomboidea.*

The principal characters by which the present species is easily distinguished from other similar triassic forms, consist in the broad conica shape of the shell, the small number of sub-angular whorls, covered with transverse striæ of growth, interrupted on the sinus, and with other somewhat stronger striæ in spiral direction. The band lies on the perpendicular portion of the whorls, a little below the angular convexity of each; it is very narrow, with the usual concave striæ of growth, and bounded on either side with a fine groove. On the basis of the last whorl the striæ become nearly obsolete; umbilicus largely open.

Locality: Lilang on the Lingti river; rare in the limestone East of the village, and seldom observed in other places in Spiti.

V. *Cephalopoda.*

The present number of known triassic Cephalopoda from Spiti amounts to 18, but there is every hope that it will be largely increased.

Three species of *Orthoceras* are all identical with Alpine forms from the upper triassic beds, namely, *Orth. salinarium, latiseptum* and *dubium*, Hauer. One species of Nautilus is described as new, but it is remarkably similar to *N. brevis*, Hauer. Of *Clydonites* two new species have been found. Of *Ammonites** twelve species are noticed; five of them are European, namely, *Am. floridus, difissus, Gaytani, Ausseanus* and *Studeri*; the rest have been previously described either by Prof. Oppel or Blanford (loc. cit.), and only two are designed as new. Besides these there are fragments of four different species of Ammonites, too imperfect to be named and described. One of these species is very like *Am. minimus*, Hauer (Sitzungsb. d. k. Akad. Wien, 1860., vol. XLI., pl. 2, figs. 1-4), and is probably identical; it differs only in its greater size, which exceeds 2 inches in diameter. What appears strange is, that not a trace of *Am. Aon*, which is so

* My friend, Prof. *E. Suess* of Vienna, tells me in a letter of the 26th December 1864, that he will shortly lay before the Academy a paper on Cephalopoda, with regard to several points in the organisation of the shell and its connection with the animal. The "Globosi" will form, he says, a new genus *Arcestes* (*vide.* Strachey's Pal., p. 66). However, not being as yet aware in what way Prof. Suess will restrict or extend this genus, I had better not introduce it here now.

common all through the Alps in these rocks and also North of Kumaon, (from Col. Strachey's researches) has been as yet found in Spiti. No doubt farther enquiries will reward the observer. As regards Ammonites, I would only mention that there exist large numbers of some species in our collection, which have throughout a constant elliptical shape. F. von Hauer and others have already previously on several occasions drawn the attention to similar asymmetry: instances of which, I would quote from *Am. Gerardi* or *Am. Batteni:* not to be thought of as any accidental compression, because we have often exactly similar specimens from three or four far distant localities, and among them not one specimen which would give a regular spiral.

I. ORTHOCERAS, *sp.*

Besides the three species noticed farther on, I have to draw attention to a remarkably thin and many-chambered species, which occurs east of Lilang in the triassic limestone, and is probably new; but I have not been able to obtain any sufficient material.

1. ORTHOCERAS SALINARIUM, *Hauer*, 1846, Ceph. des Salzkammergutes, Wien, p. 42, pl. 11, figs. 6-8.

The species is easily recognized by its broad, distant and not very concave septa. It has been met with in Spiti at *Khar*, and *East of Kuling* in the Pin valley, at *Lilang* and West of *Losar*. The specimens are perfectly identical with those from Hallstadt.

2. ORTHOCERAS LATISEPTUM, *Hauer*, 1846, Ceph. d. Salzkammergutes, Wien, p. 47, pl. 11, figs. 9-10.

Only one fragment has been found at *Khar* in the Pin valley. The form of the shell, with the very small angle of the convergence of the sides, the distant septa with their strong upper excavation and the central sipho easily distinguish the species from *Orth. pulchellum*, Hauer, (1850, Haidinger's Abhandlg. p. 1, pl. 1, figs. 1-3). Our specimen, being a cast only, does not exhibit the fine transverse striation noticed by F. von Hauer.

3. ORTHOCERAS DUBIUM, *Hauer*, Haidinger's Abhandlg. Wien, p. 260, pl. 7, figs. 3-8.

Several specimens have been obtained at Lilang, the largest of 150 mm. They agree well with specimens which we possess from Hallstadt. Only the septa are in our specimens usually not so distant, the

width being greater than the height; this, however, is a character of considerable variation, as noticed by von Hauer, loc. cit. p. 261. The fine striæ which, according to Hauer's observations, are sometimes visible on the interior of the shell, are not present on our specimens, but the thickness and smoothness of the exterior layer of the shell is quite identical with the Alpine forms.

II. Nautilus.

4. NAUTILUS SPITIENSIS, *Stol.* Pl. IV., fig. 2.

Naut. testa discoidea, parum involuta; superficie reticulata; anfractibus paucis, sub-angulatis, lateraliter complanatis; dorso convexo, lato; septis numerosis; suturis simplicibus, lateraliter concavis, interne lobatis. Siphunculo eccentrico, prope marginem superiorem posito.

Proportions calculated from figured specimen (whole diameter being considered as 1.00) in diameter of ...	40 m.m.
Outer whorl : whole diameter	0.42
Width of umbilicus : ditto	0.35
Thickness of section : height	0.82
Distance of the siphuncle from the inner margin of the septum : its height	0.60

Shell discoid consisting of only two whorls, which are not very involute, leaving a large umbilicus perforated in the middle. The section of the whorls is sub-angular, these being flattened at the sides and slightly convex on the back. The surface of the shell is covered with fine reticulate striæ, of which those in transverse direction are somewhat finer, forming on the outer periphery a deep sinuation to backwards. The septa are numerous; the sutures simple, concave on the sides, nearly straight on the back and with a small lobe on the inner margin of each septum. The siphuncle is eccentric nearer to the outer region, being placed at about one-third distance from the interior margin.

Locality: Lilang on the Lingti river; the figured specimen is the only one which has been as yet noticed. Were it not for the position of the siphuncle, it would be impossible to separate the present form from *N. brevis*, Hauer (1860. Sitzungsb. d. k. Akad. Wien. vol. XLI., p. 121, pl. 2, figs. 5-8) from the Alpine Trias. Should farther discoveries prove, that the position of the siphuncle is so far variable as to become

dorsal, the separation would be inadvisable and moreover unnecessary. I may just remark, that I have myself observed among cretaceous Nautili variations in the position of the siphuncle in different stages of age.

III. Clydonites, Hauer.

5. CLYDONITES OLDHAMIANUS, *Stol.* Pl. IV., fig 4.

Cly. testa globosa, involuta, transversaliter subcostata; costis continuis atque divisis. Suturis lateraliter (usque ad umbilici marginem) quadri-lobatis, lobis cuspidatis, sellis rotundatis, alternatim minoribus.

The globular form and the larger umbilicus distinguish this species easily from *Cly. ellipticus*, Hauer, (1860, Sitzungsb. d. k. Akad. Wien., vol. XLI., p. 16, pl. 5, figs. 8-14). The ribs divide repeatedly from the umbilicus and are coarse. The sutures have four lateral lobes on each side, so far as they are visible, up to the edge of the umbilicus; they are sharply pointed and unequal among themselves: the saddles are simply rounded and alternately longer and shorter. On the whole the sutures are equally and similarly formed to those of *Cly. ellipticus*, but the latter are more numerous and the lobes are all equal in length.

Locality: Lilang on the Lingti river; a single specimen only has been as yet found; it is not perfect.

6. CLYDONITES HAUERINUS, *Stol.* Pl. IV., fig. 3.

Cly. testa sub-globosa, lævigata; umbilico aperto; ultimo anfractu eccentrico, aperturam versus prolongato; dorso rotundato, in medio anfractuum interiorum sulcato; suturis lateraliter trilobatis, simpliciter sinuosis.

Shell sub-globose, somewhat laterally compressed, thickest round the umbilicus, which is open and becoming larger on the last whorl. The surface is apparently smooth, only covered with very fine striæ of growth. The inner whorls shew three distant sulcations in one circuit, indicating the previous positions of the mouth, on the middle of the back they are provided with a slight groove, which disappears on the last, or, probably more correctly on the body-whorl; the striæ are seen falcated on this groove.

The last whorl is somewhat prolonged and becomes eccentric. The aperture is not preserved on the figured specimen, but on another specimen it is seen simply extended with a deep furrow close

to its margin; quite similarly formed as in *Cly. ellipticus*, Hauer, (1860. Sitz. Vienna Akad. vol. XLI., p. 128, pl. 5, figs. 8-14), which our species resembles in its general form.

The sutures are trilobate on each side, and simply sinuated as in *Cly. costatus*, Hauer (ibid.); the lobes and saddles are roundish.

Locality: Lilang on the Lingti river; only two specimens have as yet been found.

I feel much satisfaction in naming the present species after our distinguished palæontologist *Franz Ritter von Hauer*, of the Austrian Geological Institute. His labours in tracing out the fauna of the Cephalopoda of the Alpine formations do not need to be mentioned, but he was the first who, in accordance with the newer and more uniform system of classification of the Mollusca, suggested a separation of the Cephalopoda into more numerous genera, a system so greatly objected to by many palæontologists, and yet so much desired by others, who endeavour in their researches to arrive at conclusions consistent with those of the classifying Zoologist.

IV. Ammonites, Brug.

7. AMMONITES FLORIDUS, *Wulfen, sp.*

1847. *Hauer* in Haidinger's Abhandlg. I., p. 22, pl. 1, figs. 5-14; —1865, *Salter* in Strachey's Palæont., p. 61, pl. 6, fig. 1, and pl. 8, figs. 1-3.

The sutures of our Himalayan forms exhibit in the dorsal lobe some slight difference from those of the Alpine species figured by *F. v. Hauer*; the specimens are otherwise undistinguishable, as noticed by Mr. Salter.

We found the species at Lilang on the Lingti river in Spiti, and it had been previously observed on the Rajhoti pass North of Kumaon by Col. R. Strachey.

8 AMMONITES JOLLYANUS, *Oppel.*

1864. Palæont. Mittheilungen, p. 271, pl. 75, fig. 4.

The interrupted depressions on or near the middle of the sides are very much like those of *Am. floridus*. The umbilicus is usually a little larger than represented in Prof. Oppel's figure, but it is always very shallow. The whorls are numerous; five inner volutions being exposed in one of our specimens, which does not exceed in size the

figure above referred to. With regard to this character it is very like *Am. planodiscus, Salter* (Strachey's Pal., p. 63, pl. 8, figs. 5-6), which may be only a young specimen of *Am. Jollyanus.*

The sutures are very exactly drawn in Oppel's figure.

The species was first found by the Schlagintweits at Kuling in the Pin valley, in which locality I observed it myself. It occurs at Muth oftener than any other fossil, and one of the largest specimens, brought in 1861 by Mr. W. Theobald, measures 180 mm. in diameter. On this specimen the last whorl represents exactly the same compressed and cuspidate section as in *Am. floridus.* The sutures, which before had only a resemblance, become also perfectly like in both. Were it not for the total involution of the last named species, nobody could distinguish fragments of outer whorls of *Am. Jollyanus* from those of equal size of *Am. floridus.* To the many variations already traced out in *Am. floridus* several more may be added in time, when we have procured sufficient materials. In such cases especially, it becomes clearly visible, that the inquiry into a species is by no means completed by giving it a specific name.

9. AMMONITES KHANIKOFI, *Oppel.*

1864. Pal. Mittheilungen, p. 275, pl. 76, fig. 4.

The lateral ribs undergo a good many variations; they are stronger and less numerous on the outer than on the inner half of the shell. However, even the former (those on the outer half) are sometimes twice as numerous as in Oppel's figure. On the middle of the sides, where the two portions of the lateral ribs join together, there are sometimes small tubercles formed at short distances from each other; they are not constant even on one and the same specimen, and do not certainly indicate a new form. If this is to be the principal character of Dr. Oppel's proposed new species *Am. propinquus,* (ibidem, p. 275, non *Am. propinquus,* Stoliczka, 1863, Pal. Indica, 3. ser., p. 23, pl. 30, figs. 1-2), it cannot be regarded as sufficient.

The umbilicus is sometimes very narrow, in other even smaller specimens larger. The whorls have usually their greatest thickness round the umbilicus, as noticed by Prof. Oppel.

But exceptions to this are not uncommon, and the shell is here sometimes more depressed than in the middle of the whorls. If a large

specimen can be spared so as to be broken, for examination, all these variations can be very often observed on one and the same specimen.

The sutures are clearly visible in Prof. Oppel's figure. In young specimens the saddles are perfectly rounded, as in *Ceratites*; growing larger, they become slightly and gradually more undulated and incised. Our largest specimen measures 75 mm. and consists still of air-chambers only.

The species has been observed at Kuling and at Muth; at the first named locality and in Ngari Khorsum it was also collected by the Schlagintweits.

10. AMMONITES GAYTANI, *Klipstein.*

1843. Oestliche Alpen, p. 110, pl. 5, fig. 4.—F. v. Hauer in Haidinger's Abhandlg. 1847, I., p. 266, and 1850, III., p. 17.)

We possess only one fragmentary specimen from *Kuling*, it shews the flattening of the sides and of the back very clearly, and cannot be mistaken for *Am. subumbilicatus*, Bronn, as noticed by F. von Hauer, loc. cit.

Mr. Salter (in *Strachey's* Palæont., p. 65, pl. 7, figs. 7-8) refers to this species a few specimens from the Rajhoti pass. They may belong to this species, but the sutures figured on his plate 7 (fig 8, c.) exhibit many differences both from our specimens and from the Alpine originals.

11. AMMONITES DIFISSUS, *Hauer.* Pl. V., fig. 4.

1860. Sitzungsb. d. k. Akad. Wien, XLI., p. 144, pl. 4, figs. 11-13).

The Spiti specimens, found at *Kuling* and *Lilang*, are quite identical in form and ornamentation with the Alpine. The two transverse furrows, indicating stages of growth, are not so strongly marked in most of our specimens, but they are seen disappearing towards the middle of the back in exactly the same way as mentioned by Hauer. The lobes have not been as yet traced in the Alpine specimens, and we give, therefore, a figure of them from one of our specimens; it may serve for comparison in future.

Col. Strachey found the species previously on the Rajhoti pass North of Kumaon.

12. AMMONITES AUSSEANUS, *Hauer.*

1847. Haiding. Abhandlg. I., p. 267, pl. 8, figs. 6-8.

Several specimens of different size have been met with at Lilang, and are perfectly identical with those known from the Alpine Trias. Three or four transverse furrows at short distances are distinctly visible, the shell is otherwise smooth. On the Rajhoti pass, North of Kumaon, it has been observed by Col. Strachey. (*Vide* Strachey's Palæont., p. 65, pl. 7, fig. 2, and probably fig. 4 too).

13. AMMONITES GERARDI, *Blanford.*

1863. Journ. As. Soc. Beng. p. 132, pl. 2, fig. 6, 1864.

1864. *Am. cognatus*, Oppel, Pal. Mitth., p. 285, pl. 81, fig. 3.

Both the existing figures by Messrs. Blanford and Oppel are taken from casts, and are not very characteristic, although so far sufficient, as to enable the species to be recognized. The transverse ribs, which on well preserved specimens (unless very young) are always very clearly visible, have their greatest thickness on or about the middle of the sides, and become thinner towards the umbilicus and towards the back. The number of ribs is usually from 16 to 18, and there are sometimes thinner ribs or striæ intermediate between them, as indicated in Prof. Oppel's figure. The greatest thickness of the whorls is round the umbilicus, which is very deep with perpendicular walls. The species attains a large size; one of our specimens from Kuling measures 125 mm. Specimens of elliptical shape are usually met with, having perhaps retained their original form, and not being only disfigured in consequence of lateral pressure of the rock.

Am. Gerardi is one of the most common triassic fossils in Spiti, it has been observed at Muth, Khar, Kuling, Silang, Lilang and East of the Kunzum pass. *Dr. Gerard's* original specimens must have been collected somewhere near Drangkhar, and Messrs. Schlagintweit found the species in Ngari Khorsum at Shangra, East of Puling.

14. AMMONITES MEDLEYANUS, *Stol.* Pl. IV., fig. 5.

Am. testa globosa, lateraliter compressa, sublævigata, prope peripheriam una serie tuberculorum ornata; dorso rotundato, transversim multice costato, costis in lateribus sub-obsoletis; umbilico angustissimo, apertura ovate-elongata. Septis lateraliter quinque lobatis, sellis uniforme bipartitis, earumque ramulis brevibus, subfoliaceis, lobis angustissimis atque profundis.

Proportions taken in diameter (considered as 1.00) of	..	95 m.m.
Outer whorl : whole diameter	... ...	0.53
Width of umbilicus : ditto	... ...	0.10
Greatest thickness of section : height	... ...	0.78

Shell sub-globose, laterally compressed, thickest round the umbilicus, sloping gradually from this to the outer periphery, the edge of which is ornamented with a row of tubercles. Only slight ribbings are seen on the sides, although it seems probable, that they were more strongly marked on the preserved surface of the shell. The back is roundish and crossed by numerous short costæ, which are slightly bent forward. The aperture is elongated ovate, much indented by the preceding whorl; umbilicus very small.

The sutures are laterally five-lobate; the saddles are all uniformly divided, bipartite, with short phylliform branches, and much broader than the lobes; the first lateral lobe is the longest, and the others diminish gradually in size towards the umbilicus.

The species is one of the interesting compressed Globosi, of the form of *Am. Studeri*, Hauer, *Am. Dontianus*, Hauer, and others.

The single figured specimen, the only one yet known, was in the collection of the Thomason College at Roorkee, an l was, with a great number of other Spiti fossils, putat our disposal by Major J. G. Medley, R. E., Principal of the College. These fossils were those collected by Captain Hutton, and subsequently purchased for the college with his other collections. It is no doubt a triassic Ammonite, and judging from the matrix, I would believe it to be from Kuling in the Pin valley.

15. AMMONITES STUDERI, *Hauer.*

1857. Sitzungsb. d. k. Akad. Wien, XXIV., p. 146, pl. 1, figs. 1-4.

The identity between the Himalayan and European triassic fossil does not require much explanation more than referring to *F.Hauer's* excellent description and figure. I will mention only a few peculiarities. The number of transverse ribs amounts in our specimen to 15 only; in proceeding towards the periphery they curve slightly backward, becoming nearly obsolete or at least less distinctly marked. On the back, which is rounded, there is clearly a tendency to recurve forwards visible. Through the striæ of growth, which on the well

preserved shell are of considerable strength, this flexuous bending of the ribs can be followed without difficulty. As regards this point *F. von. Hauer* refers justly to the similarity of this species with *Am. Dontianus*, Hauer. (Denksch. d. k. Akad. Wien, II., p. 116, pl. 19, fig. 6) also a triassic species from the Alps.

The sutures of our specimen agree perfectly with *Hauer's* figure.

Locality: Muth in the Pin valley, rare.

16. AMMONITES THUILLIERI, *Oppel*.

1863. *Ceratites? Himalayanus*, Blanford, Jour. As. Soc. Beng., pl. 133, p. 2, fig. 7, (non *Am. Himalayanus*, D'Orb. Prod. I., p. 332).

1864. *Ammonites Thuillieri*, Oppel, Palæont. Mittheilungen, p. 277, pl. 77, fig. 3. (? Ibidem *Am. Voiti*, Oppel, p. 276, pl. 77, fig. 1, & *Am. onustus* Oppel, p. 277, pl. 77, fig. 2.)

1865. *Ammonites Blanfordi*, Salter, in Strachey's Palæont., 1865, p. 66, pl. 6, fig. 2, (non *Am Blanfordianus*, *Stol.* 1863, Pal. Indica, 3. ser., p. 46, pl. 26.)

The ornamentation of this species is generally well marked and characteristically shewn in *Prof. Oppel's* figure of *Am. Thuillieri.* Blanford's original figure is too indistinct, taken from a water-worn cast. The number of lateral ribs, which are always somewhat flexuous, amounts usually to 24, and many of them become bipartite on or about the middle of the sides. The tubercles along the edge of the umbilicus are either well marked, and remain so in every size of the species, or they disappear gradually altogether. The same thing takes place with the tubercles on the edge of the back. On some specimens they are very distinctly marked, while on others they never become developed, and the ribs form slight prolongations of the back. The thickness of the whorls and the size of the umbilicus are not very variable, although the former loses much in its appearance, when the ribs are thinner. Young shells possess a roundish keel, which becomes obsolete with advancing age; the back remains, however, always convex and somewhat elevated. The saddles of the sutures are perfectly rounded in the first stages of growth and become gradually divided into short foliations. The largest of our specimens from Lilang measures 120 m.m.

Am. Thuillieri is common all through the triassic rocks of Spiti; the best specimens are those from Kuling. The variations, which I have previously noticed, can be sometimes observed on one and the same specimen. I have broken for that purpose several, and, so far as I can judge, cannot admit, that any of the variations noticed indicate different species.

The original specimen of Prof. Oppel's *Am. Thuillieri* was found at Muth, where I have collected it myself.

Another specimen was brought by the Messrs. Schlagintweit from East of the Kunzum pass, and this one Prof. Oppel names *Am. Voiti.* There seems to be, however, very little chance of its being a different species. I have observed *Am. Thuillieri* myself at or near the same locality (3 miles West of Losar), although I have not found a specimen exactly like to *Am. Voiti.* A glance on *Prof. Oppel's* figure shews a difference from the type in the smaller size of the umbilicus and somewhat more compressed whorls, but neither of these exceeds the limits of variation, which we observe among our specimens. The direction and number of ribs are in both of Dr. Oppel's figures the same, and equally are the divisions of the sutures perfectly identical.

With regard to *Am. onustus,* Oppel, I can only regret, that such fragments are thought worthy of specific names. I cannot distinguish it from similar waterworn fragments of *Am. Thuillieri* in our collection. *Dr. Oppel's* remark, that the indentation in the section (fig 2. b. loc. cit.) may be too small, is most probably quite correct. The more distant lateral ribs are not sufficient to indicate a new species.

Am. Blanfordi, Salter, is a similar fragment, like *Am. onustus;* the ribs and tubercles are somewhat better preserved on it, but it does certainly not belong to a new species.

Somewhat more doubt exists as regards *Am. Winterbottomi,* Salter, (in Strachey's Palæont. 1865, p. 63., pl. 7, fig. 5) from the triassic limestone of Ngari. *Mr. Sowerby* was in this case probably more correct, when he marked a slight keel in figures b and c (loc. cit.), although Mr. Salter denies its existence distinctly. If a keel is really present, then we are, I believe, very nearly able to pronounce its identity with *Am. Thuillieri.*

After these remarks on the Indian materials, I may be allowed to allude to their greatest ally from the Alpine Trias of Europe, namely *Am. binodosus*, Hauer, (Denksch, d. k. Akad. Wien, vol. II., p. 114, pl. 19, figs. 1-4). A comparison of the Indian fossil with F. von Hauer's original specimens, which served him for examination, would no doubt be very desirable. The resemblance to *Am. Luganensis*, Merian, (F. von Hauer in Sitzungs b. d. k. Akad. Wien, 1855, vol. XV., p. 408, pl. 1, figs. 1-2) is also worthy of notice. The last of the two species just named has a keel, the former none.

There will, I hope, be no difficulty in settling many points of difference about the Himalayan species, as good material is in the hands of two of our best palæontologists in Europe. I have retained the name of the best figured specimens of Professor Oppel, *Am. Thuillieri*, as D'Orbigny's name *Am. Himalayæ* relating also to a Himalayan species (which D'Orbigny seems to have seen in *Sir R. Murchison's* collection,)* would possibly lead to collision with *Am. Himalayanus*, Blanf., which name would otherwise have priority.

17. AMMONITES MALLETIANUS, *Stol.* Pl. V. fig. 1.

Am. testa discoidea, subelliptica; anfractibus numerosis, subrotundatis, lateraliter costatis: costis crassis, circiter 26 in uno circuitu, simplicibus, nontuberculatis. Dorso angustato, (convexo atque lævigato; umbilico magno, ad margines abrupto; apertura) ovali, postice cordata. Suturis lateraliter trilobatis, multice dissectis, sella dorsali parva, lobo laterali primo longissimo, tripartito: ramulis sellarum subfoliaceis; suturis auxiliaribus trilobatis, inæqualiter divisis.

Proportions calculated from the figured specimen

(diameter being considered as 1.00) in diameter of	...	102 mm.
Outer whorl : whole diameter	... ...	0·31
Width of umbilicus : ditto	... ...	0·47
Thickness of section : height	... ...	1·09

The shell consists of numerous rounded whorls, which are involute, for about half their width leaving a large umbilicus with steep walls. The greatest thickness of the whorls is near the edge of the umbi-

* If the specimen exists, there may be some chance to get D'Orbigny's name a signification, but otherwise not. It refers probably to *Am. biplex* or *Braickenridgii*, Sow, or any other Ammonite of the "Planulati."

licus, and the shell slopes from here gradually towards the outer periphery. On the sides there are about 26 short ribs to one whorl; thick, but not much elevated, without any tuberculations, and disappearing towards the back and the umbilicus. The section of the whorls is ovate and cordate, the back being roundish.

The sutures have only two lateral tripartite lobes; the dorsal saddle is very small, and all have numerous phylliform branches; the first lateral is of all the lobes the longest. The auxiliary sutures are unequally subdivided, except the first, short but broad auxiliary saddle, which seems to have its bipartition regularly on or close to the edge of the umbilicus.

The species has a remote affinity to *Am. modestus*, Buch.; I am not aware of any other known form like our Himalayan species. It is named after my friend, F. R. Mallet, of the Geological Survey of India, my companion during our survey in 1864. Having previously visited Spiti in 1861, Mr. Mallet was able in several instances to facilitate the progress of our work.

Locality: Lilang on the Lingti river; the figured specimen is the only one as yet known.

18.—AMMONITES BATTENI, *Strachey*. Pl. V. fig. 2., Pl. VI. fig. 1. 1865, Palæont., Pl. XI, fig. 2, ibidem, p. 64, Pl. VI, fig. 4.

Am. testa discoidea, oblonga; anfractibus numerosis, lateraliter valde compressis, sublævigatis interdumque prope umbilicum subcostatis, parum involutis; dorso rotundato, non carinato; umbilico magno, subplano; apertura elongate-compressa. Suturis lateraliter bilobatis, numerosissime atque profunde incisis; lobo dorsali brevi et lato, lobis lateralibus longioribus, inæqualiter tripartitis; sellis latis, prope tripartitis, ramulis subfoliaceis; suturis auxiliaribus multilobatis, umbilicum versus oblique descendentibus atque gradatim minoribus.

Diameter of largest specimen from Muth ... ... 350 mm.
Length of the shell : width, *or*, longer : shorter
diameter ... ... *1.24 to †1.30

* Specimen figured on Plate V., fig. 2.

† Plate VI., fig. 1.

Proportions calculated from figured specimens (the whole diameter being considered as 1.00) in the longer diameter of	68	„	1.40
Outer whorl : whole diameter...	0.25	„	0.32
Width of umbilicus : ditto	0.57	„	0.40
Thickness of section : height	0.58	„	0.44

The two figured specimens, of which the smaller has a greater number but somewhat less involute whorls, may be accounted as the principal varieties of this species. All our specimens (9) have the peculiar elliptical shape, although they come from three different localities. This form is therefore not accidental, but characteristic. The surface of the whorls is either smooth or bears sometimes short transverse ribs, which disappear towards the back. Laterally the whorls are always strongly compressed, higher and somewhat more embracing when less numerous, (fig. 1, pl. 6.); thicker and less involute when there is a greater number of them present, (fig. 2, pl. 5).

In the ornamentation of the shell and in the divisions of the sutures the varieties are perfectly identical. There is a broad, but short dorsal and two lateral lobes, of which the first one is the longest; they are unequally tripartite; the dorsal saddle has longer branches on the side of the siphuncle, and is, like the next lateral on its upper termination, unequally tripartite; all the branches are approaching to phylliform. The auxiliary lobes are numerous and descend obliquely towards the umbilical suture, similarly as in *Ammonites* of the cretaceous group " *Ligati.*"

Mr. Salter noticed a fragment (loc. cit., p. 64) of this species, but regarded it justly, as insufficient to name. A second fragment was figured among jurassic fossils by Col. Strachey on Plate XI and named below *Am. Batteni.* Mr. Blanford tells me that, so far as he can remember the fragment, it agrees quite with our specimens, but that he found it much too imperfect, and has therefore omitted any farther notice of it in his descriptions. I have, in consequence of this, retained Col. Strachey's provisional name. The species must have been only accidentally mixed with other jurassic fossils.

Localities: Muth, Kuling in the Pin-valley, Lilang on the Lingti river.

VI. Vertebrata.

Mr. Theobald found in the triassic beds East of Kuling a bi-concave vertebrum, and I got a few pieces of other bones in probably the same locality in the Pin valley. The vertebrum is hollowed out in the middle. It is impossible to say at the present, whether these fragments of bones belong to Reptiles or fishes even. Col. Strachey tells me, that he found a number of *fish teeth* in the triassic beds North of, or somewhere near, the Niti pass, but that they have been lost in some way, and he has not been able to recover any of them. We may, therefore, get in time some more information about triassic fishes from the Himalayas.

Section 2.—Rhœtic.—Para-limestone.*

In Northern Spiti there is above the Trias a thickness of some hundred feet of limestone, which, according to its fossils, seems justly to be called by the above name, as representing this Alpine formation in the Himalayas. The Para-limestone does not exist in the southern part of the Spiti valley, (above the Trias and below the Tagling limestone,) or we must have failed altogether to trace it out. Certainly it does not exist here with the characteristic bivalves, if it is to be found in reality, which I do not intend to deny. Traces of the Para-limestone are to be met with in the Parang section, but I remember having seen it, only in a few loose blocks, ascending the Pass towards the camp Bhaonrhochan, and I have therefore not noticed it in the section. It cannot be more than a few feet in thickness, if compared with the thousands of feet of the other limestones, in the North-western portion of Spiti, and not far to the West from the Parang road, the Para-limestone is well developed. It is a black, in some beds very earthy and strongly bituminous, limestone, which does not effervesce, or hardly effervesces at all, with acids. In the Alps this kind of magnesian limestone is generally called *dolomitic limestone.* It has a fine granular structure if compact, and breaks into small angular pieces, or usually, if thin-bedded, it is earthy. Where the Tagling stream (Lagudarsi river) joins the Spiti river, the thickness of the Para-limestone amounts to about 700 feet, its position above the Trias and below the Tagling limestone is here undoubted, and its mineralogical characters are quite different from those of both the other limestones. The fossils contained are *Megalodon triqueter*, *Dicerocardium Himalayense*, several species of *Chemnitzia*, of the character of those from the Esino-dolomit, and *Neoschizodus.* Towards the South the Para-limestone is seen decreasing in thickness, and probably disappears near the village Ki, or South of

* I mean to apply this name to the beds with *Megalodon triqueter.*

Kibber, altogether, but I did not follow it in this direction. In the western part of the Spiti river towards Losar it thins out gradually, and opposite to this village, to the North, it is seen only near the tops of the hills of about 100 to 200 feet in thickness. Towards the Tagling pass the thickness of the limestone without doubt increases (at least partially), and amounts probably to more than 1,000 feet on the other side of the Baralatse range in the Para valley. As it is here so very extensively and characteristically developed, I have adopted for this limestone a name from the river Para. I shall say a few words in the general summary in justification of the name *Rhætic*, and farther as regards its relation to other formations.

RHÆTIC FOSSILS.

The few fossils, which have been just now referred to, do not all permit a very accurate determination, and I would mention particularly, and as characteristic, only two; one is *Megalodon triqueter*, Wulf., a common Rhætic fossil in the Alps, and universally known as the "Dachstein bivalve;" the second belongs to a genus only newly established, and is specifically allied to a species from the same beds in the Southern Alps; a *Dicerocardium* allied to *Dic. Curionii*, Stoppani.

DICEROCARDIUM HIMALAYENSE, *Stol.* Pl. VII.

Dicer. testa magna, cordiformi, umbonibus valde protractis, externe subcarinatis atque contortis; superficie concentrice-crasse-lamellosa.

A cordiform, large bivalve with very much extended and somewhat spirally turned umbones; its form is that of a reversed cone, the basis of which is bordered with a rounded edge, which runs all along the outer side of the prolonged umbones. The hinge does not exhibit, so far as seen on our specimens, any particular teeth or grooves; it must be very similarly formed to that of *D. Curionii*, Stoppani. The surface is only covered with coarse, lamellar, ribs and sulcations of growth. The shell has a very great thickness, especially at the umbones, which consist, to a considerable extent towards their terminations, of a solid mass of shell. This latter has a spathic fracture, resembling much that of fossil Echinoderms.

The genus *Dicerocardium* has been only lately (1364, Pal. Lombardie 3. ser. 14-19, p. 248) published for the first time by Abbé Stoppani. The author describes, from the beds of *Megalodon triqueter*, Wulf. (*Megal. Gümbelii*, Stopp.), two species, large *Diceras-like* bivalves, which he amply illustrates; *Dic. Jani and Dic. Curionii.* The former is by much more slender than our Himalayan species, and exhibits besides many other differences. *Diceroc. Curionii* is, however, very like ours. The much coarser ribbing, more prolonged umbones, and the want of a special keel on their outer edge may separate the two forms, so far as Stoppani's representations allow a decision.

Locality: Two (one of which is only a half) specimens have been obtained East of the village *Chiote* in the North-west part of Spiti, but the specimens (and probably more than one species) are innumerable all through the Rhætic limestone in Northern Spiti, and in the Southern districts of Rupshu.

MEGALODON TRIQUETER, *Wulfen.* 1793.

1862. Gümbel in Sitzungsb. d. k. Akad. Wien, Vol. 45, pp. 325, etc.

Specimens of different size up to one foot in diameter occur in the Para-limestone in the North-western parts of Spiti and in Rupshu. I got from the Para valley two specimens, which leave no doubt about their identity with the Alpine forms. The specimens are quite different from any young ones of Dicerocardium.

Stoppani, in the last part of his publication of the Palæontologie Lombardie, which we have received in Calcutta, (3 Ser. 14-19), proposes on pp. 219-220 to abolish the old signification of the species altogether and to adopt a new name, *M. Gümbelii*, Stopp. If M. Stoppani could change all the papers in which the old signification of *Cardium triquetrum* has become familiar, there would be less objection to his well intended proposition, supposing that all other conchologists agree in this new treatment of palæontological literature. When Mr. Gümbel's paper on the "Dachstein-bivalve" was published, there were, I believe, very few palæontologists, who, after looking through that carefully executed work, did not think the matter settled, and who did not know the meaning of *Megalodon triqueter*, Wulf. Every one must confess, that hardly anything was left to be done

in the way of tracing out Wulfen's and other author's names, as to their real significations. But suddenly a new *southern breeze* arises and seems to overturn all which had been rebuilt with great pains. I do not think it is strong enough to surmount the Alps and reach safely to the North! It will probably meet a strong current from the opposite direction. In mercantile matters the name of an old firm has a great value, and is retained, if possible, for many generations, simply on account of its being known and universally accepted. There is nothing, which we can see, different in the case of the Dachstein-bivalve. The question with regard to the Geological position of *Megalodon triqueter* will be found more fully discussed in our conclusion.

Section 3.—Lias. Tagling-limestone.

Above the triassic beds follows a thickness of limestones of about 2,000 feet. The lower strata of these limestones correspond partly with the well known "Kössner-schichten" of the European Alps, and the upper seem to represent the liassic limestones, known under the name "Hierlatz-schichten" of the same mountain-ranges. I shall mention my palæontological reasons why, for the present, it seems preferable to describe both these limestones under one series, and separate them merely as lower and upper beds. The name is principally intended for the upper beds, the equivalents of the Hierlatz strata, and I shall, in my next survey, endeavour to ascertain whether the distinction of the lower beds into a separate group will find any more support, than now indicated, or not.

a. Lower Tagling-limestone.—Lower Lias.

A dark brown or grey, sandy or earthy, and mostly fine oolitic limestone is the principal rock of this series. It sometimes consists chiefly of fragments of shells, and the name of shell-limestone could be justly given to such strata. Beds of compact blueish limestone are rarer, but oftener they are earthy, and break into small angular fragments, like the dolomites of the Alps. It is not difficult to distinguish even pieces of this limestone from similar rocks of the triassic beds; the latter weathers out on the surface generally blueish-white or black, the former rusty, light brown, and the sandy elements are recognized at the first glance.

Stratigraphically this series is an exceedingly well marked one. Beginning again in our Bhabeh section from Muth, a large thickness of what I believe to be this limestone can be traced towards the tops of the hills on both sides of the Pin river. While the triassic limestones are very much disturbed and contorted, the lower Tagling limestone rests on these nearly horizontally, or is at least hardly affected by those disturbances. From a place,

a few miles East of Kuling, where the lower Tagling limestone comes down in a deep ravine, and where numbers of *Nerineæ* can be observed in it, I do not think that I am much mistaken in the explanation of the previous portion of the section, although we have never been able to ascend any of the higher ridges in the Pin valley.

Along the whole extent of the Spiti-shales, which will be described next, the lower Tagling limestone can be seen everywhere, and (with the exception of one locality South of Gieumal,) immediately below the shales, so that the upper Tagling limestone is wanting here altogether. At several localities round the villages Gieumal, Longja, Tshissigaong, Kibber and Chikkim the lower Tagling limestone contains the most characteristic fossils in immense quantities. The *Terebratula gregaria* and *Rhynchonella Austriaca* can be collected in thousands; *T. pyriformis*, *T. Schafhœutli*, *T. punctata* and *Rhyn. fissicostata* and others are somewhat less numerous, but still many specimens are to be had. With these Brachiopoda occur undoubtedly the Belemnites, and all the other fossils, which I describe from these beds. There is certainly no possible mixture with the fossils from any other strata excepting the fossils of the shales, and where this seems to have taken place, I shall mention the case.

The geographical extent of these limestones is very great. Inasmuch as these beds are the highest in all Southern and South-western parts of Spiti, they are more exposed on the surface than the preceding older rocks. Their extent to North-west and South-east is probably greater than that in Spiti, but has not as yet been determined.

FOSSILS OF THE LOWER TAGLING LIMESTONE.

The following is a review of the fossils from these beds.

I. *Brachiopoda*—10 species; all identical with European liassic forms, and most of them occurring in the beds known as *Strata of Kössen*, or *Avicula-contorta beds:—Terebratula gregaria*, *Rhynchonella Austriaca*, etc.

II. *Pelecypoda*—about 14 species; some of them as *Pecten Valoniensis, Avicula inæquivalvis*, and others are very characteristic.

III. *Gastropoda*—several species, but none of particular interest.

IV. *Cephalopoda*—two species of Ammonites, one of which is most probably *A. Germanii*, and three new species of Belemnites.

I. *Brachiopoda.*

1. TEREBRATULA GREGARIA, *Suess.*

1864. Deslongchamps in Pal. Franç. Terr. Jur. Brachiopoda, p. 64, with references to other authors. The species occurs in very great number, and we possess hundreds of specimens in all stages of growth, and of manifold variations. These are exactly similar to those which are known as *T. globata* or *perovalis*, Sow. The *Ter. Paueri* of Winkler is no doubt only a young *T. gregaria*, of which Schafhœutl in his Süd-Bayern. Lethæa geognostica (pl. LXX., figs. 2 and 3) gave a few representations. This species is especially common in the upper beds of the *Lower Tagling limestone*, immediately below the Spiti shales, in the neighbourhood of Gieumal, Longja, Kibber, Chikkim, &c.

It occurs in the *Kössner-schichten* of the Alps, in the lower Lias of France, &c. I have no doubt that Professor Salter's specimen figured (Strach. Pal. p. 100, pl. 21, fig. 6) under the name of *T. globata* belongs to this species; indeed it is not very easy to find out very characteristic differences between the liassic and oolitic fossil.

2. TEREBRATULA PYRIFORMIS, *Suess.*

1864. Deslongchamps in Pal. Franç. Terr. Jur. Brachiop. p. 70, with other references. Several very characteristic specimens of this species have been found with *T. gregaria* at Gieumal; and at Tshissigaong the species is less common, and often not so wide as those occurring in the "Kössner-schichten." Deslongchamps quotes it from the *lower lias* of Langres (Haute-Marne), where it ought to occur with *Gryphæa arcuata.*

3. TEREBRATULA PUNCTATA, *Sow.*

1864. Deslongchamps in Pal. Franç. Terr. Jur. Brachiop. p. 160, with other references. Only two specimens have been found with the previous species at Gieumal; they are in every respect perfectly iden-

tical with similar specimens, which the Survey collection possesses from the Marlstone of Clandown near Radstock. The length of the loop is exactly the same as figured by Davidson from Sowerby's original specimen, and distinguishes the species from *T. carnea* or *ornithocephala*. The punctuation is as well seen in one of our specimens. I cannot believe that M.Deslongchamps is quite correct in referring Oppel's *T. sinemuriensis* to this species, and shall state the reasons farther on, (p. 80). The specimen figured by Prof. Salter in Strachey's Palæont. pl. 21, fig. 5, and described (p. 99) under the name *T. carinata*, Lam., belongs probably to this species, and I am not certain whether even fig. 4 (ibid.) does not represent a depressed variety of the same species.

Ter. punctata is usually quoted from the middle Lias, but Deslongchamps (loc. cit. p. 164) allows it to go as far as the upper beds of the lower Lias, and I do not see any reason why it ought not to be found in the lower beds as well. The specimens figured by Quenstedt (Jura. pl. 9, figs. 1-3) (from Lias α) seem to exhibit very little difference.

4. TEREBRATULA (WALDHEIMIA) SCHAFHÆUTLI, *Stoppani.*

1857. Stud. Geol. p. 109. Numerous specimens have been found with the other Terebratulæ at Gieumal, and they are undoubtedly identical with the Austrian specimens from Hirtenberg.

The species has been described at first by Prof. Suess (1854. Denksch. d. k. Akad. Wien, Vol. VII., pt. II., p. 38) under the name of *T. cornuta*, Sow. Prof. Suess had compared at that time a very large series of *T. cornuta* with the Kössen Terebratula, and had arrived at the conclusion that both are the same species. I really do not know whether any body, after having compared again such a series, would not come to the very same conclusion! I must say, for my own part, that I am unable to fix any certain differences between the lower liassic species of the Himalayas and the true English *Ter. cornuta.* The only more remarkable difference is, that the lower-liassic (Kössen) specimens are nearly always somewhat slender towards the beak, and that the beak itself is more prominent. There are, however, very similar forms to be found under the middle-liassic *T. cornuta.* Prof. Suess seems to have himself given up the identity of the Kössner with Sowerby's species, as he proposed the name *Waldh. norica* for it. (*Vide* Sitzungsb. d. k. k. Geol. Reichsanstalt, vol. X., p. 46.)

The name quoted above *T. Schafhæutli*, Stopp. is that which is now usually accepted for the species by Alpine Geologists.

5. RHYNCHONELLA OBTUSIFRONS, *Suess.*

1854. Denksch. k. Akad. Wien, Vol. VII., pt. II, p. 55, pl. IV., fig 12. The Himalayan specimens are generally much larger than those from the Kössner-schichten, of which I have compared 12 specimens, but in all other respects they are perfectly identical. Prof. Suess (loc. cit. p. 56.) remarks, that larger specimens of the same species have been found plentifully in the Hierlatz-schichten (of the middle Lias), and that they show a great amount of variation. Probably it has been, from the latter strata, described by Professor Oppel under the name of *Rhyn. Emmerichi*, (Zeitsch. d. Deutsch. Geol. Gesellsch. vol. XIII., p. 542, pl. XII., fig. 1.)

Our specimens vary in their thickness; some of them being quite as much depressed as the specimens from Enzesfeld near Vienna, others are more inflated, and the fold and sinus are more strongly expressed. The usual number of the plications on the fold is three, and two corresponding ones on the sinus; rarely there are only two plicæ on the fold, but sometimes four are to be met with.

There can be no doubt that the species occurs in the German Lias; but the great number of different forms, which usually go under the universal name of *Ter. triplicata*, require a thorough revision.

6. RHYNCHONELLA PEDATA, *Bronn*, sp.

1854. Suess in Denksch. Akad. Wien, Vol. VII., pt. II., p 61. A few specimens have been found in the uppermost beds of the Tagling limestone; although common in the sandy limestone itself, it is very difficult to obtain even one perfect specimen. I have not been able to compare any actual European specimens with our fossils, but they agree so well with Suess' figure, that there can be hardly any doubt as to their true identity. Mr. Gümbel, in his "Geognostische Beschreibung des bayerischen Alpen gebirges", 1861, refers this species to his "lower Alpine Keuper"—triassic beds equivalent to our Lilang series.

7. RHYNCHONELLA FISSICOSTATA, *Suess.*

1854. Denksch. Akad. Wien, VII., pt. II., p. 58. This is a very characteristic species of the Kössen strata, and is not uncommon South

of Gieumal; a few specimens have been met with in the same strata below the shales North-east of Kaja and near Tshissigaong. Some of the smaller specimens from Gieumal can be well attributed to the *R. fissicostata*, var. *applanata* of Gümbel, (Bay. Alpen-gebirge, p. 401), they are lenticular, very flat, and the sinus scarcely marked at all.

8. RHYNCHONELLA AUTSRIACA, *Suess.*

1854. Denksch. Akad. Wien, VII., pt. II., p. 53. All our specimens agree perfectly with the smaller and thinner ribbed variety, which Professor Suess mentions from Bernreuth, one specimen from which locality we have compared with ours. Among several hundreds of specimens we do not possess a single one of the inflated and more coarsely ribbed variety, which is figured by Professor Suess, and which is identical with Quenstedt's figs. 13-14. (pl. 22, 'Jura') of *T. Austriaca.* Specimens quite similar to this latter variety have been, however, collected by my friend Mr. Mallet in 1860 somewhere near the Niti pass; their exact stratigraphical position is not known.

9. RHYNCHONELLA VARIABILIS, *Schloth.*

1852. Davidson, Brit. Brach. pt. III., p. 78.—1854, Suess in Denksch. Akad. Wien, VII., pt. II., p. 56. Of this species only one specimen has been found South of Gieumal, but several have been met with in the same beds in Rupshu; they agree fully with compared specimens from the marlstone near Radstock, and undergo the same variations as regards the number of plicæ on the fold and sinus.

Prof. Salter mentions the species from Col. Strachey's collections from the neighbourhood of Niti. (*Vide* Strachey's Palæontology, p. 101.)

10. RHYNCHONELLA RINGENS, *Herault, sp.*

1852. Davids. Brit. Brach. pt. III. pl. 74. Our specimens from the South of Gieumal in general agree well with L. von Buch's and Davidson's figures and descriptions.

The principal variation exists only in the number of costæ on the sinus, there being from one to three of these and correspondingly from 2 to 4 on the mesial fold; the usual number in the sinus is only two, as in most of the British or French specimens, somewhat more rarely there is only one and very seldom there are three in the sinus. Our specimens have real costæ in the sinus better expressed than in the European, but there is no other difference in form

or ornamentation of the shell. The species is quoted by D'Orbigny from the upper Lias; Mr. Davidson (loc. cit. p. 75) is inclined to believe that it occurs in the lower oolite, from which it is quoted also by Morris (Cat. p. 149). Professor Oppel says (Jura, p. 432) that it probably occurs at the base of the lower oolite. The species has, I believe, not been noticed as yet from Germany.

It is well worth while to draw attention to Rouillier's *Terebratula bidens* (Phill.), var. *primaria, secundaria* and *tertiaria,* in the Bull. Soc. de Moscou 1848, pl. F., figs. 4-7, and T. *triplicata* (Phill.) *typica,* ibidem fig. 8. All these figures agree very well with our specimen, and as regards the costæ in the sinus even better than those previously quoted.

II.—Pelecypoda.

1. OSTREA, *conf.* O. ACUMINATA, Sowerby.

Ostrea acuminata, Sow. Salter in Strachey's Palæont. p. 91, pl. 22, fig. 3. The Himalayan specimens are so much like the common oolitic fossil, that there seems little chance indeed to separate them. What I can perceive as a little difference is, that the muscular impression lies at about half of the height of the shell in the oolitic *O. acuminata,* and that it is rather rounded (*vide* Chapuis, Foss. d. Luxemburg 1853. pl. XXXII, fig. 6), while in our fossil the impression is more elongated and placed much closer to the apex.

This small oyster is a very characteristic fossil of the Lower Tagling limestone, and occurs, associated in great quantities in beds, exactly like *Ost. acuminata.* It is decidedly not from the Spiti shales, but occurs always below, in a quite different limestone, and with the characteristic Brachiopoda previously quoted.

2. OSTREA, *conf.* O. ANOMALA, Terq. (Mém. Soc. Geol. France, V. p. 25, fig. 4.)* One specimen, which is not unlike Terquem's figure of a lower liassic species, has been found with *T. gregaria* North-east of Kaja.

3. AMUSIUM *sp.*

It is, I believe, high time that we adopted some systematical arrangement as regards the universal denomination *Pecten,* otherwise the quota-

**N. B.*—Great confusion exists here as to the references to the text and explanation of plates.

tion of quite different forms as being identical will have no end. The three genera, as fixed by Messrs. Adams, *Pecten, Vola,* and *Amusium,* will probably answer best for the pressing wants of the present. It will perhaps be necessary to accept more genera, but for that purpose a critical examination of all known Pectens is unavoidable. It is especially in the genus *Amusium* that a difference in colour and ornamentation of the two valves nearly always occurs, and, to characterize a new species, both the valves ought to be known, otherwise repetition in naming one and the same species can scarcely be avoided.

Our present species under consideration has been figured and noticed by Prof. Salter under the name of *Pecten lens,* (Strachey's Pal., p. 94, pl. 22, fig. 8), a species which is a true *Pecten* with unequal ears, and has nothing whatever to do with this *lower liassic species.* We have the true *Pecten lens* from the Spiti shales, and could only in this way account for some inexplicable mistake in figure and type. Our specimens are exactly like Prof. Salter's figure, only some of them are still a little narrower posteriorly.

As I have no materials whatever to compare with, and as a number of similar species have been described already by Quenstedt, Zieten, etc., and lately numbers of new species have been named by Gümbel from the same strata, I rather prefer not to name the species.

I would especially suggest the comparison of *P. sepultus,* Quenst. (Jura, p. 48, pl. 4, fig. 11) and *Pecten glaber,* Zieten, (pl. 53, fig. 1). According to the account given by Quenstedt of *Pect. glaber* there seems to exist a great deal of confounding of different forms under one name. Common near Gieumal and North of Kibber.

4. PECTEN, *conf.* P. PALOSUS, *Stol.*

1861. Sitzungsb. Akad. Wien, Vol. 43. p, 197, pl. 6, fig. 8.

One specimen from the South of Gieumal seems to be quite identical with the species which I have described from the Alpine "Hierlatz-schichten." The radiating ribs are somewhat closer on our specimen; this may be, however, expected on the preserved shell; my Alpine specimens were chiefly casts.

5. PECTEN MONILIFER and P. SABAL, *Salter,* in Strachey's Palæont. pp. 93 and 94, pl. 22, figs. 10 and 11. We possess only one specimen of the right valve; a complete cast. The ears are small and

unequal. The ribbing consists of 6 stronger radiating and tuberculated ribs (*P. monilifer*), and each of these has another smooth secondary rib on either side (*P. sabal*). It is therefore just as correct to attribute our specimen to either of the two species, which I would rather believe are not specifically different. As Salter's examination rests only upon fragments, the question about their identity must be postponed until better materials have been obtained. It is of no use to name fragments even when 'from eternal snows'! I must also remark, that it does not seem to me quite certain, whether the species comes from the lower Tagling beds, and whether it is not rather a triassic one, allied to *P. moniliferus*, Bronn (in Münster's Beitræge 1841. p. 72, pl. VII, fig. 4) from the St Cassian strata. Our specimen was brought by Mr. Theobald in 1861 from Mikkim in the Pin-valley. I have passed over the same locality, but not met with any more specimens. There are, except carboniferous, only triassic rocks down at the river, and the matrix of the specimen is indeed somewhat like to some beds of the light-coloured triassic limestone. Lower Tagling limestone occurs, however, plentifully above the Trias, a few hundred feet higher, so that the specimen may come just as well from a block of this limestone.

6. PECTEN BIFRONS, *Salter*.

1865. in Strachey's Palæont., p. 92, pl. 22, figs. 5-7, *in parte*. There is no doubt very great confusion as regards this species, and we could only wish a revision of the materials collected by Col. Strachey. Surely, they must come from different strata!

I cannot attempt now to fix the species, as our own materials are not sufficient; a few remarks, however, may be found useful. Fig. 5 of Prof. Salter's *P. bifrons* represents undoubtedly a species from the upper jurassic (*Gieumal sandstone*). I have collected myself this species above Gieumal in the calcareous beds of this sandstone. Fig. 6 is doubtful, but probably the same species as represented in Fig. 7. This is a species quite different from the jurassic one; it is a more rounded shell, apparently more convex, and has smaller ears; the biplicate ribs are much better expressed. This latter form is from the lower liassic beds; and there is still a third biplicate species from the same beds, which is quite as oblique as a Lima.

7. PECTEN VALONIENSIS, *Defr.*

1856, Oppel and Suess in Sitzungsb. Akad. Wien, Vol. XXI., p. 548, pl. II., fig. 8.

1861. Moore in Quart. Jour. Geol. Soc. Lond., Vol. XVII., pl. 16, fig. 6.

Several specimens have been found South of Gieumal with the characteristic Brachiopoda of the "Kössen" strata. They are exactly like the European fossil and cannot be mistaken, although usually only of small size. Possibly Mr. Salter's fig. 12 on pl. 22 in Strachey's Palæontology may represent a specimen of this species. Mr. Salter remarks, that it occurs with the liassic *Cardium truncatum*, Sow.

There have been lately from the same strata in Europe so many new and allied species established, that it would be no wonder to see the *Pecten Valoniensis* meet with the same fate as many other old known species. When we cannot get out of the confusion, which we ourselves have induced, we then propose to abolish these old names, as has been attempted with *Lima gigantea, Am. biplex*, and many others.

8. LIMA DENSICOSTA, *Quenst.*

1861. Sitzungsb. Akad. Wien, Vol. 43, p. 199, pl. VII., fig. 3.

The Himalayan form, found in the lower Tagling limestone, South of Gieumal, agrees even better with Quenstedt's fig. 24, pl. 18 (in his 'Jura') than with that which I have described from the Hierlatz-schichten of the Alps. It is quite as oblique and narrow as Quenstedt's original figure.

In the paper quoted above I have referred to several similar species, and it seems to me now more probable, than before, that many of these liassic little Limas with simple ribs are not specifically different. It is not to be expected, that we have in every zone of one formation altogether a different fauna. Neither the conditions nor the species could make such rapid progress in their changes.

9. AVICULA INÆQUIVALVIS, *Sow.*

1861. Sitzungsb. Akad. Wien, Vol. 43, p. 198. The true European species, with unequal intermediate ribs, occurs in the lower Tagling limestone near Gieumal and South of the Parang-pass with *T. gregaria, Rhynch. fissicostata*, etc. It is now generally admitted that the

liassic species is not different from the jurassic, but we cannot possibly allow the variation so far as to regard Prof. Salter's representation of *A. inæquivalvis*, in Strachey's Palæont. p. 91, pl. 22, fig. 13, as the same, if the figure be really correct, as it appears to be. I would rather say Prof. Salter's figure represents a specimen of *A. echinata*, Sow.: it would, however, be a somewhat more coarsely ribbed variety, such as do occur, though not usually, in the Gieumal sandstone.

10. AVICULA PUNCTATA, *Stol.* Pl. VI., fig. 2.

A. testa oblique ovata, inæquilaterali, parum convexa; auriculis inæqualibus; auriculo antico majore, sinuato; superficie lineis radiantibus, ad peripheriam curvatis ornata, interstitiis punctatis.

A very slightly convex valve, very oblique, approaching in form to a parallelogram. The shell is thin, nacreous, as usually in the genus *Avicula*, and the surface is ornamented with numerous, towards the periphery slightly curved, elevated lines, the intermediate grooves being finely punctated. The ears are equal, the anterior one much longer, slightly sinuated at the end, with flexuous lines of growth, and with a deep sinus on its basis.

Locality. The species has been met North of the Manirang pass and South of Gieumal.

11. GERVILLIA, *sp.*

Only very imperfect specimens have been found South of Gieumal, resembling very much the *G. olifex* of Quenstedt, (Jura, p. 86, pl. XI., fig. 4) from Lias *α*.

12. ARCA, *sp.* (Macrodon).

A single specimen from the South of the Parang pass, (below the camping ground Bhaonrhochan,) does not shew any difference from *Arca Lycetti*, Moore, (Quart. Jour. Geol. Soc. Lond., 1861, pl. XVI., fig. 7) from the Rhætic (*Avicula contorta*) beds.

III.—Gastropoda.

1. DENTALIUM, *sp.*, not unlike Prof. Phillip's figure of *D. giganteum* (Geol. Yorksh. pl. XIV. fig. 8) from the Marlstone series. South of the Parang pass.

2. NERITA, *sp. nov.*, from North of Kaja on the ascent towards Hikkim; quite a globular and smooth form, to which I do not know any European ally.

3. NATICA, *conf.* PELOPS, *D'Orb.* (Pal. univ. pl. 288, figs. 16-17, from the upper Lias). One specimen from North-east of Kaja, apparently undistinguishable from D'Orbigny's figure.

4. CHEMNITZIA, *conf.* CH. COARCTATA, *Desh.* (D'Orbigny, Pal. univ. p. 45, pl. 240, figs. 1-3) from the lower Oolite. Near Kibber several specimens were obtained (in the lower Tagling limestone) of a *Chemnitzia*, which is perfectly like the jurassic species, but it is impossible to pronounce identity, as none of our specimens is complete.

5. CHEMNITZIA, *sp.*

A few specimens of a little *Chemnitzia* have been found with *Rhyn. fissicostata* and *Ter. gregaria* North-east of Kaja, below the Spiti shales; they recal very much D'Orbigny's *Ch. Phidias* from the lower lias, (Pal. univ. II., p. 34, pl. 237, fig. 12), only the angle of the spire is a very little larger in the French species.

6. NERINEA, *sp.*

North-east of Kaja *Nerineæ* occur very plentifully in the lower Tagling limestone with *T. gregaria*. They are in general like those which I have to mention from the upper beds, and which in form resemble *N. Goodhalii*, Sow., but I have never observed them, neither here nor South of Gieumal, of that large size, being usually thin and often with an obtuse vertex.

I met also with several *Nerineæ* in the Pin valley, a few miles West of the mouth of the Pin river. As I am, however, well aware of the difficulties which exist in the determination of this genus, and how variable even the folds* are—generally believed to be the best character of a *Nerinea*—I shall not endeavour to establish new species until really good materials have been provided.

IV.—Cephalopoda.

1. AMMONITES, *conf.* GERMANII, *D'Orb.*

Pal. Franç. Terr. Jur. I., p. 520, pl. 101. A single specimen, which we possess from the North of the Manirang pass, and which is a cast only, agrees well with D'Orbigny's figures and descriptions. The number

* It is, I believe, known, that they usually become weaker and often disappear altogether near the mouth; sometimes one or the other fold disappears at half the height of the spire, others become stronger.

of transverse sulci is 6 in our specimen: *Am. interruptus*, (Zieten's Petref. Würtembg., p. 25, pl. XV., fig. 3.) which is identical with D'Orbigny's *Am. Germanii*, has 7 transverse sulci, and in D'Orbigny's figures the number varies from 8 to 10. This seems to be, therefore, a point of great variation. There is no other objection whatever to identify our specimen with *Am. Germanii.*

2. AMMONITES, *conf.* MACROCEPHALUS, *Schlotheim.*

Two specimens, both not very well preserved, were brought by Messrs. Theobald and Mallet in 1861 from the North of the Manirang pass in Spiti. Except a finer ribbing they do not seem to differ from the *Am. macrocephalus* in the Spiti shales. I found, besides, several undistinguishable fragments and a little perfect specimen in the Para valley of Rupshu (together with *Terebratula gregaria, Rhynchonella variabilis* and *Austriaca*, and others,) and cannot give at present any positive characters to distinguish it from the jurassic species. Form of the shell, ribs and sutures seem to be quite similar, but the striation is always finer.

3. BELEMNITES BUDHAICUS, *Stol.* Pl. VI., figs. 3-6.

Guard cylindrical, very slightly tapering towards the end, smooth, without any vascular impressions visible; in front with a deep furrow, which extends from about the middle of the guard to its lower termination; the section is usually circular.

The species must have attained a great length, as no trace of the alveole is to be seen on any of our specimens (fig. 4 being the largest). They are very often, and at different localities, found with a number of transverse breaks, which are no doubt accidental, but they have the appearance of some kind of joints.

Localities: South of Gieumal, near Tshissigaong and West of Chikkim; found loose in the beds below the Spiti shales.

4. BELEMNITES BISULCATUS, *Stol.* Pl. VIII., figs. 1-4.

The guard is smooth, with two furrows; one in front and one opposite to it, the latter being narrower and shorter, and not extending up to the lower termination, while the former terminates near the point broadly, but shallow. The dorsal groove is sometimes much shorter than the ventral. The section is, on the upper portion of the guard, where both the furrows exist, oval with the longer diameter in the line of

the furrows: towards the end, where the dorsal furrow gradually disappears, the section becomes oval in the opposite direction, the guard being somewhat compressed in the line of the furrows of this species; the guard resembles some species of the *Hastati*. No vascular impressions or any kind of secondary grooves near the point are visible.

The angle of the guard measures about 15°; both the sulci on it are narrow, and deeply cut in the surface of the shell.

Localities. Loose specimens have been found below the Spiti shales near Gieumal, Tshissigaong and West of Chikkim. South of Gieumal the species occurs plentifully in the hard Tagling limestone with *Terebratula gregaria, Rhynch. ringens, Austriaca, fissicostata,* and others. With the same fossils, I have observed it in Rupshu near Tatang-yogma in the Para valley; there can be, therefore, not the slightest doubt as regards this species being really from the same beds as the other lower liassic fossils.

5. BELEMNITES TIBETICUS, *Stol.* Pl. VIII, figs. 5-6.

A cylindrical guard resembling *Bel. digitalis.* The surface is quite smooth, and on some of the small specimens two fine and only very short grooves near the point are indicated, others have slight and simple vascular impressions on the sides. On larger specimens not anything of both is usually visible, but the guard has on its upper portion a slight groove in front, and the shell becomes at the same time somewhat slender. The section is nearly round, sometimes a little compressed laterally. Nothing of the alveole is seen on any of our specimens.

Localities: Round Gieumal very common in the limestone, and loose, below the Spiti shales. At Tshissigaong and Chikkim the species was found with the previous, and one specimen has been met with in the lower Tagling limestone, South of the Parang pass. The co-existence of this species with *T. gregaria, Rhynch. fissicostata* and *Austriaca,* &c., is, therefore, certain; it seems, however, to occur in the upper beds also. The only allied species which I can find among European Belemnites is a species from the Lias at Gammelshausen in Würtemburg, noticed and figured by Zieten (p. 29, pl. 22, fig. 4) as *Bel. semihastatus.* It would be worth while to compare these two forms.

Section 4. (*b*) *Upper Tagling limestone.—Middle Lias.*

This is a dark blue earthy or dolomitic limestone, which occupies the top of the portion of the Baralatse range North of Spiti. In its mineralogical characters it resembles some of the Alpine limestones of exactly the same age, as for instance those on the 'Gratzalpe' near Aussee, in Upper Austria. (*Vide* Sitzungsb. d. k. Akad. Wien, 1861. Vol. XLIII. p. 157). It requires careful attention to distinguish it in pieces from the Para limestone or the beds with *Megalodon triqueter.* I do not know anything about the further geographical extension of this limestone, but its superposition on the *lower Tagling limestone* on the Parang and Tagling passes is an undoubted fact.

On the Parang pass I collected several Gastropoda in this limestone, identical in species with those from the Alpine "Hierlatz-schichten," of which I wrote a Monograph quoted above. I mention here as the more common forms *Chemnitzia undulata* and *Trochus epulus,* as being the best known fossils. Fragments of Belemnites occurred with these Gastropoda, of which latter none has been observed in the lower limestone. On the Tagling pass I noticed, however, in this upper limestone a *Nerinea,* apparently not different from that of the lower beds, and also the *Belemnites bisulcatus* (?) or at least a species very like it. On account of the limited extent, to which the upper limestone is as yet known, and of its palæontological relations, I think it better for the present not to define it quite strictly, although I rather believe that it may be possibly separated, so soon as the country has been more thoroughly examined and more fossils have been collected. The partial difference of the mineralogical characters, and the superposition, are no doubt strongly in favour of this opinion.

FOSSILS.

I. *Brachiopoda.*

1. TEREBRATULA SINEMURIENSIS, *Oppel,* (Zeitsch. d. Deutsch. Geol. Gesellsch. XIII., p. 534, pl. X., fig. 2). Prof. Oppel described

the species from the lower Lias: it seems to be justly separated from *T. numismalis*, or *punctata*, Sow. With the latter it has been lately united by M. Deslongchamps, (Pal. Franç. Brach. 1864, p. 160). Our specimens, five in number, have been collected South of the Parang pass; no other fossils have been met with, and I do not wish to express full confidence in my placing the species in the upper beds of the Tagling limestone, as the strata might possibly belong to the lower series, although the limestone itself agrees much better with the upper beds. I believe this species differs from similar specimens of *T. punctata* by a longer and less incurved beak, larger deltidial plates, much finer septum, narrower and shorter adductor-impressions. Besides *T. punctata* is nearly always posteriorly obtuse; *T. sinemuriensis*, so far as visible on Oppel's figures and on our specimens, is equally rounded or even somewhat prolonged.

It is hardly necessary that we should trespass on our space by giving a new figure of the Himalayan form; the five specimens, which we possess, vary only a little in their width, but are otherwise exactly like Prof. Oppel's figure.

II. *Pelecypoda.*

MODIOLA, *sp.* resembling the oolitic *Mytilus subreniformis*, M. & Lyc. (Great Ool. Foss. pt. II, p. 39, pl. IV., fig. II). A single specimen, which is imperfect and appears to be from the upper beds. It was found near the Parang pass.

III. *Gastropoda.*

1. NERITOPSIS, *conf*, N. ELEGANTISSIMA, *Hörnes*, Sitzungsb. Akad. Wien, Vol. 43, p. 179, pl. 3, fig. 7—from the middle liassic strata of the Alps, the Hierlatz-schichten. Several very like and most probably identical specimens have been met with on the top of the Parang pass.

2. CHEMNITZIA UNDULATA, *Reuss*, (*Stoliczka*, in Sitzungsb. d. k. Akad. vol. 43, p. 163, pl. 1, fig. 1). Specimens obtained on the top of the Parang pass are perfectly identical with those described by myself from the *Hierlatz-strata* of the Austrian Alps.

3. TROCHUS LATILABRUS, *Stol.* (ibidem, p. 173, pl. 2, fig. 9,) from the Parang pass, undoubtedly identical with the Alpine liassic species.

4. TROCHUS EPULUS, *D'Orb.* (Stoliczka, ibid. p. 167, pl. 1, fig. 11.) from the Parang pass; it is a common liassic fossil in the Alps and in North France.

5. TROCHUS ATTENUATUS, *Stol.* (Ibid. p. 171, pl. II., fig. 1). A few specimens from the Parang pass seem to belong to this species, but they are too badly preserved to be determined with required certainty. I believe the species, which Mr. Etheridge (Quar. Jour. Geol. Soc. Lond., Vol. XX., p. 388) quotes as *Cerithium?* like *C. muricatum*, Sow. sp. from Captain Godwin Austen's collection of Himalayan fossils, is the same as ours. It is no doubt from the same beds, only farther to North-west than our locality.

6. ENCYCLUS, *sp.* from the top of the Parang pass. The single specimen is too imperfect for description.

7. ACTEONINA, *conf.* CINCTA, *Goldf. sp.* Petref. Germ. III., p. 48, pl. 177, fig. 9. D'Orb. Prodrome I., p. 247.

One specimen from the Parang pass agrees pretty well with Goldfuss's figure, which represents a specimen from the liassic strata at Banz. It is only a cast, with cylindrical whorls on which the spiral furrows are very well marked. It may be an *Acteonina*, which generic name D'Orbigny proposed instead of Goldfuss's original name *Tornatella*. The spire has no folds whatever, but this point is not mentioned at all by Goldfuss.

The specimen has been found on the Parang pass by Mr. W. Theobald, and I believe from the matrix that it belongs to the upper series of the Tagling limestone.

8. NERINEA, *conf.* GOODHALLII, *Sow.* Trans. Geol. Soc. Lond. IV., pl. 23, fig. 12.

In referring to a similarity of the Himalayan specimens with the English fossil from the Calcareous Grit, we do not wish to express more than what is externally seen on imperfect specimens. I have no doubt* that *Mr. Etheridge* (Quart. Jour. Geol. Soc. London, Vol. XX., p. 388) means the same species, which he says is allied to *N. Goodhallii*. The specimens, which I obtained on the Parang and farther to North-west on the Tagling pass, differ from the English *Nerinea* by a greater number of internal folds. Our specimens have three folds

* From Capt. Godwin Austen's personal communication.

on the spire, one on the upper lip and two on the outer lip. Of the last two the lower is by much stronger than any of the others. The concave and smooth whorls are apparently quite like to those of *N. Goodhallii.*

IV. Cephalopoda.

BELEMNITES *sp.* On the top of the Parang, as well as on the Tagling pass, I have noticed fragments of Belemnites in the limestone with the other Gastropoda. From their much elongated form I believed them on the spot to be identical with *Bel. bisulcatus* (nov. sp.), although I am unable at present to ascertain it fully.

AMMONITES *sp.* (conf. MACROCEPHALUS, *Schloth.*) Mr. Theobald has brought from the North of the Manirang pass (?) specimens, and I found myself another small specimen in Rupshu in beds with *Tereb. gregaria,* etc. It is really difficult to pronounce any thing quite certain about this species, as all the specimens are not well preserved. They differ from compressed varieties of *Am. macrocephalus* merely in the finer striation.

Section 5. Jurassic—Clayey Slates.

In the Section Nos. 2 and 3 on Plate II, I have noted a small thickness of beds South of Gieumal, between the Tagling limestone and the Spiti shales. At this locality the position of the slates is unquestionable, between the Tagling limestone and the Spiti shales. Their mineralogical characters are different from those of the rocks above and below.

The beds consist of thin layers of clayey black or brown slates, which contain a very great quantity of little fragments of different *Mollusca,* as if they had been formed only from the aggregated debris of shells. In fact, these beds, the whole thickness of which does not

exceed 50 feet, seem to be quite a local deposit; I have not observed them at any other locality in Spiti; although I have examined the superposition of the Spiti shales and the Tagling limestone at more than one place.

Of fossils I could recognize only fragments of *Belemnites*, which do not admit of a specific determination, and a *Posidonomya*, which I am unable to distinguish from *P. ornati*, Quenst. Some of our specimens are well preserved, and they agree perfectly with Quenstedt's figure in his Petrefactenk. pl. 42, fig. 16. Figure 27, as given on plate 67 in the "Jura," does not seem to be so characteristic. *Pos. ornati* occurs with *Am. ornatus* in the German Jura, and Oppel (Jura, p. 567) says that he found it in England in beds above the *Am. macrocephalus*. This last-named species does not occur in Spiti at the same locality, but a little above these slates, although in the lowest beds of the Spiti shales.

I have often thought whether these slates ought not in some way to represent the Upper Tagling limestone, which, on the top of the Parang pass, contains liassic Gastropoda; but the Posidonomya is certainly not identical with *Pos. Bronni*; it could, if this supposition were to receive any farther support, be only a new species. I have quoted this small thickness of beds separately, merely because they are really lithologically different from the others, and, should any thing be done in the way of working out different beds in the jurassic deposits of the Himalaya, these slates may then receive more attention.

Section 6. Spiti Shales.—Oolitic.

Not one of the other formations is lithologically so remarkably and easily distinguished as the Spiti shales, from which beds most of the Spiti Ammonites have been long known since Dr. Gerard's first discoveries.

In the middle portion of the valley, and from 2,000 to 3,000 feet above the left bank of the Spiti river, there extends (from North-west to South-east) a longitudinal ellipse of these rocks. The length of this ellipse is about 20 miles only, and the greatest width never exceeds 5 miles; being in the southern part generally only 3 miles or even less. The geographical extent of the ellipse is marked by a great number of villages, of which Gieumal is the most southern and Chikkim the most northern; these two villages lie near the extremities of the ellipse.

The rock itself is a black, crumbling shale, breaking into little angular fragments when dry, and easily decomposing to a black soil when wet. Calcareous concretions occur more or less numerously throughout the series, and contain often, as a nucleus, an Ammonite, a Belemnite, or some other fossil.

These shales overlie the 'Lower Tagling limestone' *conformably*, and dip everywhere towards the centre of the ellipse. It is, however, generally very difficult to observe any regular stratification in them, resulting from their crumbling and easily fractured nature and easy decomposition. A stream runs generally on the boundary between the two formations. The thickness of the shales is usually only 2 or 300 feet, and hardly ever exceeds 500 feet.

We have not observed them beyond the extent of the said ellipse, neither in Rupshu nor in Spiti itself, and accordingly all the still younger formations do not extend beyond the limit of the shales.

A great number and variety of fossils are known already from these rocks through the researches and labors of others, but there is still much to be done. I have attempted to give a revised catalogue

with notes on all the species, which are known in Spiti from these beds, and have excluded others, which belong to other formations. I need hardly say anything more here, than I have already stated speaking of the triassic fossils. Every attention has been given to avoid any confusion with fossils from other beds.

With regard to my views, expressed in the palæontological notes themselves, and relating to different species, I have been guided not only by my previous studies and some little experience, but by a comparison of actual European specimens as well. Should my opinions appear doubtful or even perhaps exaggerated as to one point or the other, I am gladly responsible for them; without pretending that they are absolutely correct. But they are derived, I know, from good materials and not through any careless work. I shall be just as glad to give them up as soon as they are proved to be incorrect by any future discoveries. Neither a small nor a great number of species can satisfy the palæontologist or the geologist, if he is always in doubt about their determination; but descriptions of *specimens* from different localities *as species* is mischievous.

FOSSILS OF THE SPITI SHALES.

The following is a list of all fossils known from the Spiti shales.

Echinodermata (?)—Mr. Blanford notes a *Salenia* from Spiti (Journ. As. Soc. Bengal, 1863, p. 137, pl. II. fig. 9); the original is very defective, and even the genus doubtful. The locality of the specimen is unknown.

I.—*Brachiopoda*; two species, one of which is the common oolitic *Rhyn. varians*, Schloth.

II.—*Pelecypoda*, 17 species; *Pecten lens*, *Nucula cuneiformis*, *Astarte major* and *unilateralis*, *Trigonia costata* and some species of the genus *Ancella* are the most characteristic.

III.—*Gastropoda*, only two species of Pleurotomaria as yet known.

IV.—*Cephalopoda*, 19 species, of which the best known European forms are, *Am. macrocephalus*, *Parkinsoni*, *curvicosta* (Opp.), *triplicatus* and *biplex*, and *Belemnites canaliculatus*. They are all oolitic species.

I.—*Brachiopoda.*

1. TEREBRATULA, *sp.* A single fragment has been met with North of Kibber near the camping ground *Tangtag;* the specimen may belong to *T. simplex,* or *ovoides.*

2. RHYNCHONELLA VARIANS, *Schloth, sp.* (1852. Davidson, Brit. Brach. p. 83, pl. 17, figs. 15-16). The species is not common in the Spiti shales; I met with only two specimens at Gieumal and one at Kibber. The specimens are undoubtedly identical with the jurassic species of Europe, and agree especially well with the inferior oolite specimens from Whatley.

II.—*Pelecypoda.*

1. OSTREA, *sp.* The Himalayan species from the Spiti shales, is no doubt allied to *Ost. flabelloides, Lam.* (Desh.), with which species Prof. Salter unites it (Strachey's Palæont. p. 90, pl. 22, fig. 1). But in *Ostrea flabelloides* and *Marshii,* both of which are perhaps identical, the ribs and furrows are sharp and angular; in our species the ribs are sharp, although not nearly so much elevated, but the furrows are much broader and roundish hollowed out. There are, however, so many similar variations known that we think it more advisable to defer the question of identity with one or the other species until we may procure better specimens; the present materials being very imperfect. The Cutch *O. Marshii* is more likely to agree with *Ost. flabelloides* in the form of its ribs and the placing of the muscular impression, which is only somewhat more elongated.

PECTEN LENS, *Sow.* (Mor. and Lyc. Great Ool. Foss. pt. II, p. 11, pl. II., fig. 1: *non idem* Salter, in Strachey's Palæont. pl. 22, fig. 8). The true oolitic species occurs in the Spiti shales, and is not to be mistaken, even in fragments, for the lower liassic *Avicula punctata, n. sp.* (p. 76). I rather believe that the species, which is figured by Mr. Salter (loc. cit. pl. 22, fig. 9) under the name of *Pecten comatus,* Münst., belongs to *P. lens,* and that some mistake must have occurred in figuring the specimens.

3. AMUSIUM, *sp. conf.* PECTEN SOLIDUS, Trautsch. 1861. Bull. Soc. Mosc. p. 76, pl. VI., fig. 4. Our Himalayan species was found North of Kibber in the Spiti shales. It agrees exactly with *Trautschold's*

figure, and possesses similarly a few distant concentric striæ, the interspaces between which are finely striated according to the lines of growth. *Trautschold* refers especially to the solid shell of the Russian species, while our specimen (only one having as yet been found) has apparently a very thin shell; but this could possibly be only the interior nacreous layer of the valve.

Already in 1806 *M. Roemer* described an oolitic species under the same name *P. solidus;* it is indeed not very unlike to that of Trautschold or the Himalayan form. *M. Roemer* remarks equally a considerable thickness of the shell.

4. ANCELLA BLANFORDIANA, *Stol.*

(*Monotis concentricus,* Blanford, 1863. Jour. As. Soc. Beng. p. 136, pl. IV., figs. 6-7: non *Ancella concentrica,* Keyserling, Petschora-land, p. 300). The genus Ancella is a very characteristic fossil for the eastern jurassic deposits, as mentioned often by Keyserling, Trautschold, Eichwald, and others. The present species is very like *Anc. Pallasii,* Keys., only the anterior portion of the valves is longer and more rounded. There are apparently no intermediate striæ in the sulci of the left or more convex valve. The characters of the thin shell are exactly the same in the Indian specimens, as they have been recorded by Keyserling, Trautschold and others.

The species is not common in the Spiti shales. The figure in Strachey's Palæont. (pl. 22., fig. 4) is not quite correct as to the form of the sinus of the right valve.

5. ANCELLA LEGUMINOSA, *Stol.* Pl. VIII., fig. 8.

Anc. testa inæquivalvis, valde inæquilateralis, oblique elongata, leguminosa; valva sinistra convexa, umbone maxime-incurvato; valva dextra subplana; superficies striis radiantibus atque concentricis, undulatis, ornata.

A very oblique, pod-like shell, on which the hinge is placed quite closely to the frontal termination. The right valve is slightly convex, with pointed umbo and a small sinus in front of it. The left valve is much more strongly convex, with an incurved beak and a corresponding elevation of the margin opposite the sinus of the right valve. Coarser and finer striæ of growth and radiating lines ornament the shell surface, they are both undulating.

Locality. Only the figured specimen has been found at Kibber.

6. LIMA, *sp.* from Kibber, very like the *L. rigida,* Desh.

There is in Dr. Gerard's collection a species of Lima with radiating ribs and numerous fine striæ between them; this would agree with what Prof. Oppel calls *L. Roberti* (Pal. Mitth. 1864, p. 273). I have not met the species myself in the Spiti shales, and as the rock of *Dr. Gerard's* specimen, which is not complete, is somewhat different, I prefer omitting here to quote it more particularly.

7. INOCERAMUS HOOKERI, *Salter,* 1865, in Strachey's Palæont. p. 98, pl. 23, fig. 1 is a true Inoceramus, so far as can be seen from the form of the shell and the dentitions of the hinge line. I have seen only casts as yet. It occurs not uncommonly in the Spiti shales at Ki and Gieumal.

8. MACRODON EGERTONIANUM, *Stol.* Pl. VIII. fig. 7.

(*Cucullæa virgata,* Blanford, in Journ. As. Soc. Beng. 1863, p. 136 *non* id. Sow.)

M. testa oblique-elongata, convexa, angusta, costis radiantibus rugosis ornata: costis ad marginem anteriorem paucioribus, ad marginem posteriorem prope obsoletis; striis concentricis inæqualibus, undulatis, interdumque lamellosis.

Shell very oblique and unequal; the anterior portion being much shorter than the posterior. The height is not considerable, but the thickness very great, and the beaks are much incurved. Strong radiating, rugose costæ ornament the shell, becoming weaker near the periphery and less numerous on the lateral terminations; they have usually no intermediate ribs between them. The striæ of growth become undulating in crossing the costæ and often lamellar near the periphery. The hinge is not different from the usual form in Macrodon, and, I believe, the sub-genus, or whatever it may be called, ought to be accepted, as the differences from Arca and Cucullæa are considerable and important. (*Vide* Morris and Lycett, Great Ool. pt. 11, p. 48.)

The present species has been long known, and has been figured by Rev. W. Everest in Vol. XVIII of the Asiatic Researches. It cannot be identical with the Cutch *Cucullæa virgata,* Sow. (Trans. Geol. Lond. V., pl. 22, fig. 1) as this shell is not nearly so oblique, is

much higher and has far more radiating costæ of unequal strength; the hinge line equally does not correspond with that of our specimens. I have much pleasure in naming the species after *Philip Egerton, Esq.*, C. S., at present Deputy Commissioner of Umritsur, who placed his interesting collection, made in 1863 in Spiti, at our disposal for examination.

9. NUCULA, *sp.*, from Gieumal; resembles *N. subovalis, Goldf.* (p. 154, pl. 125, fig. 4), and does not seem to be a *Leda.*

10. NUCULA CUNEIFORMIS, *Sow.* (Geol. Trans. V., pl. XXII., fig. 4) is quoted already by *Mr. H. F. Blanford* from Spiti. It is one of the most common fossils, and occurs throughout the Spiti shales. It is certainly identical with the Cutch fossil, of which I have compared actual specimens with it. It is a very inflate shell like *N. Hammeri, Defr.* (apud Goldfuss), but usually found distorted by pressure of the rock.

11. CYPRINA TRIGONALIS, *Blanford* (Journ. As. Soc. Beng. 1863, p. 135, pl. IV., fig. 5). No better material has been as yet procured than was known from Mr. Blanford's notice. The shel lseems to be rare. It does *not* occur in the Gieumal sandstone with *Avicula echinata,* which statement rests upon a mistake with another species.

12. TRIGONIA COSTATA, *Park.* (Sow. Min. Conch. I, pl. 85). Two specimens found at Gieumal do not differ from the common oolitic fossil of Europe. They are somewhat broader, approaching to the variety *T. pullus,* Sow., which is not specifically different from the *T. costata.* It occurs as well in the oolitic deposits of Cutch.

13. ASTARTE UNILATERALIS, *Sow.* 1840. Trans. Geol. Soc., pl. XXII., fig. 14.—id. *Salter,* in Strachey's Palæont., p. 97, pl. XXIII., fig. 10.

The flattening of the umbones, to which Mr. Salter alludes, is very remarkable, and is to be observed on all the species from this district; it seems to be a local peculiarity. On the Cutch specimens, which are otherwise undistinguishable, this flattening does not occur, at least not to the same extent, and even the concentric ribbings are not nearly so strong. The species is very common throughout the Spiti shales, and occurs always with *Nucula cuneiformis*; the species has been often considered as *Astarte major.*

It must be this species which Prof. Oppel names *Astarte Harmanni* (Pal. Mith. 1864, p. 273); the Rev. Mr. Everest's figure certainly represents it, the original specimens of which are in the Asiatic Society's collection, Calcutta.

14. ASTARTE MAJOR, *Sow.* 1840. Geol. Trans., pl. LXI., fig. 1, is much longer or wider, and not as high as the previous species; it is also generally more inflated and has a deeper lunula.

This species is much rarer in Spiti, and has been only found at Gieumal.

15. ASTARTE SPITIENSIS, *Stol.* Pl. IX., fig. 9.

Ast. testa subtrigonalis, valde inæquilateralis, umbonibus superne applanatis, acutis atque incurvis; lunula ovali, profunda; superficie striis concentricis atque rugis crassis ornata.

A large subtrigonal shell, not much inflated, covered with unequal striæ of growth and sulci. The umbones are flattened and curved inside and anteriorly; the lunula is ovate, very deeply excavated and bounded with sharp margins. The area is long, and the bounding ridges are roundish. The periphery is only slightly and partially granulated. The teeth and grooves of the hinge do not differ from the usual form in Astarte.

This species somewhat resembles in form *Ast. subtrigona*, Goldfuss, (III. pl. 134, fig. 17), in which the anterior portion is more prolonged and the lunula not nearly so much excavated. The striæ of growth do not correspond very exactly.

Locality: Chikkim and Kibber.

16. ASTARTE HIEMALIS, *Stol.* Pl. IX., figs. 2-3.

Ast. testa subtrigona, complanata, rugis concentricis crassis ornata; lunula ovali-elongata, profunda; margine ad peripheriam obsolete atque partim granulato.

Shell ovate, somewhat trigonal, the anterior and posterior parts being extended and rounded; much compressed and covered with numerous coarse sulci, which terminate on the edges of the lunula and of the area; the latter is narrow and deep; the lunula rather elongated with sharp ridges. The peripherical granulation is sometimes clearly seen, sometimes it disappears altogether. The hinge does not exhibit any peculiarities, only the muscular impressions are proportionally of large size.

Locality. This species has been met with at *Kibber, Chikkim* and *Gieumal,* but it is rarer than any of the three others, which occur with it.

17. HOMOMYA TIBETICA, *Stol.* Pl. IX., fig. 4.

H. testa valde inæquilateralis, antice truncata postice elongata, ad marginem rotundata, utrinque hians; superficie rugosim concentrice striata.

The species is very characteristic in its form: the anterior extremity being very short, truncate obliquely, the posterior much prolonged and rounded at its termination. The lower margin is slightly curved, the hinge line nearly straight. The beaks are strongly incurved, and there is below them a prominent tooth in each of the valves exactly as in *Pholadomya.* The surface is covered with concentric striæ of growth only, which are coarser in the first stage of growth than afterwards. The shell is open on both sides.

Locality: Gieumal; three specimens have been found.

III. *Gastropoda.*

1. PLEUROTOMARIA, *sp.* Two species have been noticed in the Spiti shales, both only casts and not sufficiently perfect for further determination. The one species from Gieumal (*vide* Journ. As. Soc. Bengal, 1863, pl. 4, fig. 3) has more rounded whorls: the basis of the last whorl being covered with broad spiral sulci; and the band lies above the middle of each whorl.

The second species, found at Kibber, is more turrited and the whorls are more angular, having the band on this angle in about the middle of each whorl.

[*Turritella montium,* Blanf. Journ. As. Soc. Beng., 1863, p. 134, pl. 1, fig. 7. As regards the locality it is doubtful where this shell has been collected. I do not think in Spiti. The mineralogical character is different from anything I have seen, and one, the specimen figured by Mr. Blanford, is partly incrusted by a *Membranipora,* which, I would rather say, is younger than jurassic.]

IV. *Cephalopoda.*

1. AMMONITES ACUCINCTUS, *Strachey.*

1863. *Blanford* in Journ. As. Soc. Beng. p. 126, pl. 1, fig. 3.

1865. *idem* in Strachey's Palæontology p. 87, pl. 18, figs. 1-2.

The quoted descriptions and figures will be at present sufficient to recognize the Indian fossil. With regard to the sutures I may

notice, that fig. 1*c* in Strachey's Pal. pl. 18 gives no good idea of the true form of the lobes and saddles. The figure was evidently taken from a specimen with a very much eroded surface.

Prof. Oppel's lately published descriptions and figures of Himalayan Cephalopoda offer ample materials for comparison (1864, Palæont. Mittheilungen, Stuttgart). Among the many described species of *Ammonites* I would very much desire to draw attention to the following three species: *Am. Adolphi* (loc. cit. p. 270, pl. 75, fig. 1), *Am. substriatus* (loc. cit. p. 271, pl. 75, fig. 2), and *Am. Lymani* (loc. cit. p. 272, pl. 76, fig. 3). All these three forms, described under different names, come from the Spiti shales in Ngari Khorsum, and my present belief, based upon large materials from the whole of the northern Himalayas, and to a good extent from the same localities, is, that the three forms are identical in species. I may be excused in differing so far from the views of my friend Prof. Oppel, but I may be allowed also to say that scarcely anybody would accept proof to the contrary with more thanks than myself. Figures are always apt to lead into mistakes. Every palæontologist forms his opinions from a certain amount of materials, and nobody can pretend to be absolutely correct; but insufficient material prevents much the attainment of sound conclusions.

With regard to *Am. Adolphi* and *substriatus* of Prof. Oppel, neither the descriptions nor the figures shew any specific difference, and everybody will, I think, believe these two forms to belong to the same species. The sutures are in both the same, and are respectively perfectly identical with those of *Am. acucinctus*, so that it is not necessary to figure these again. *Prof. Oppel's* figures of the two above-named species represent specimens devoid of the shell surface, and in consequence of this circumstance the flexuous ribs are less distinctly marked, and the serrated keel altogether wanting. We possess perfectly similar specimens from the North of the Niti pass.

Am. Lymani is a less involute form. Prof. Oppel examined two specimens, one from Ngari (Gnari) and one from Gieumal (Gimul) in Spiti. They seem both to have had the shell surface preserved, and the keel as well as the lateral flexuous striæ of growth were distinctly visible. At Gieumal in Spiti I have collected among many other

fossils also numerous specimens of *Am. acucinctus* and several of these have exactly such a wide umbilicus as *Oppel's Am. Lymani.* I cannot see what other species the figure ought to represent, if not this largely umbilicated variety of *Am. acucinctus;* our specimens are decidedly not different from the type, as we have satisfied ourselves from a great number of specimens of different sizes. In *Strachey's* Palæont. (pl. 18, fig. 2,) this less involute variety is marked as *Am. ac.* var. *mundus*. Among the European species *Am. acucinctus* has a good many allies. Prof. Quenstedt describes in his "Cephalop. Deutschlands" and in the "Jura" several closely allied forms, to identify which could be of no value from want of the necessary materials. *Mr. Schafhæutl* described in his "Sud-Bayern's Lethæa geognostica" (1863, p. 415, pl. 83, fig. 3) an *Am. incisus,* from which, according to the characteristic description and figure, hardly a difference whatever can be traced out. *M. Schafhæutl* says, that the species occurs with *Planulati* Ammonites; this is also precisely the case with *Am. acucinctus* as the Spiti shales might be emphatically called the *Planulati* beds, because the *Ammonites* of this group are at least ten times more numerous than those of other groups, although they do not belong to many species. Finally, I would refer again to *Prof. Oppel's* "Pal. Mittheilungen," and for the present notice only the remarkable similarity of *Am. Pichleri* (loc. cit. p. 212, pl. 31, fig. 4), which appears to be the closest ally to the Indian shell. It is to be regretted, that the lobes of the species are not figured; the description does not explain them sufficiently.

I must say, for my own part, that I have no doubt whatever that *Am. acucinctus* will be recognized among the many similar European forms, among which a reduction in the number of their specific distinctions appears very desirable.

Locality. In the Spiti shales *Am. acucinctus* is throughout very common in the Spiti valley; Mr. Mallet brought in 1860 several good specimens from the North of the Niti pass, and *Col. Strachey* and *Messrs. Schlagintweit* collected the species numerously in the same beds in Ngari-Khorsum.

2. AMMONITES STRIGILIS, *Blanford*, 1863 Journ. As. Soc. Bengal p. 126, pl. 3, fig. 1.

This is a very remarkable species, to which there is no European ally known. Since the publication of the paper referred to Mr. Blanford has succeeded in tracing out another and more complete specimen from Dr. Gerard's collection. The specimen is evidently from the shales. The ribbings begin with the body chamber, and are exactly similar to those represented in Mr. Blanford's previous figure. The outlines of the sutures resemble those of the "Heterophylli." Lobes and saddles are uniform, and in size gradually decreasing towards the umbilicus. The first lateral lobe is longer than the dorsal, and all are similarly tripartite. The dorsal and the first lateral saddle are distinctly bipartite, the following approach more to tripartition; their branches are short, but they terminate clearly phylliform. We possess only one fragment from Kibber probably belonging to this species, but it is still quite smooth in a diameter of 65 millemetres.

3. AMMONITES MACROCEPHALUS, *Schloth.*

1850. *D'Orbigny*, Pal. Franç. Jur. I., pl. 430, p. 151, or *Quenstedt's* Ceph. Deutschlands, p. 182, pl. 15, figs. 1-2.—1863, *Am. Nepalensis*, Gray, Blanford in Journ. As. Soc. Beng. 1863, p. 123, pl. I., fig. 6.

The specimens from the Spiti shales belong chiefly to Quenstedt's variety *Am. mac. compressus*. Any of the European figures can be taken as a representation of the Indian fossil, and also Quenstedt's very carefully executed figure of the outlines of the sutures. I have compared French and German specimens of the same species with the Himalayan fossil, both as regards the form of shell and the sutures, *and can warrant their full identity*. *Am. macrocephalus* has as yet been found, in Spiti, only near Gieumal, in the lowest beds of the shales. The specimen figured by Mr. H. F. Blanford (loc. cit. and deposited in the Soc. collection) is most probably from the same locality. Mr. Blanford's identification of the species with *Am. Nepalensis*, Gray, rests upon his comparison of the Spiti specimens with Gray's originals in the British Museum in London. Gray's figure itself is very coarse, and would never allow us to recognize the species, as not only the ribs are much too coarse but even their direction does not agree well.

The specimen described by Mr. Blanford, as *Am. Nepalensis* in Strachey's Palæont. p. 77, pl. 14, fig. 1, is much more allied to Gray's figure, but it is still very indistinct. Mr. Blanford assures me that it is also identical with Gray's originals, and that he thought himself, in comparing the species in the British Museum, that they were identical with *Am. mocrocephalus.*

Mr. Mallet brought a few specimens of *Am. macrocephalus* from the North of the Niti pass in 1860; the specimens from here are usually larger and some are of equal size with Gray's figure.

4. AMMONITES OCTAGONUS, *Strachey.*

1863. *Blanford,* in Journ. As. Soc. Bengal, p. 128, pl. 1, fig. 5.

1864. *Am. Sömmeringi, Oppel,* Pal. Mith. p. 280, pl. 80, fig. 1.

1865. *Am. octagonus and Hookeri, Strachey,* in Palæont. loc. cit. p. 83, pl. 12, fig. 2, and pl. 17, fig. 1.

Only fragments of this species have been figured, and the descriptions are, therefore, equally not very sufficient. The Survey collection possesses complete specimens from the Spiti valley and from the Niti pass, but we must defer to another opportunity giving a new figure. The species is no doubt much allied to *Am. Eugenii,* Rasp. (D'Orbigny Pal. Franç. Jur. I, p. 503, pl. 187), although the ornamentation exhibits a good deal of difference. Young specimens of *Am. octagonus* are at least partly tuberculated, while those of *Am. Eugenii* are only transversally ribbed. The first two rows of tubercles (counted from the umbilical edge) are in *Am. octagonus* distinctly lateral, while in *Am. Eugenii* the second one of the two is much nearer to the middle of the back.

The well preserved surface of the shell of *Am. octagonus* exhibits numerous fine striæ of growth. It is usually the case, that the dorsal tubercles become somewhat more obliterate with the age, and are connected by short ribbings with the tubercles of the outer *lateral row ;* these short ribs are always remarkably bent forward. In younger specimens, of which one is figured by Col. Strachey under the name *Am. Hookeri,* the partial obliteration of the dorsal tubercles does not occur often but it is sometimes the case, and intermediate non-tuberculated ribs are present in all stages of growth. Judging from our materials we cannot regard *Am. octagonus and Hookeri* as different species. The

fragment, which Prof. Oppel figures as *Am. Sömmeringi*, is from Spiti, and there is no doubt, I believe, of its being identical with similar pieces of this species, which we possess from different localities. I need hardly, I think, recall the resemblance which *Am. octagonus* bears to the upper liassic species *Am. Taylori*, Sow., and especially to the figure given by D'Orbigny in his Pal. Franç. Terr. Jur. pl. 102. If the tubercles on the umbilical edge of *Am. octagonus* disappear, as sometimes occurs on the last whorl and chiefly near the mouth, such fragments of whorls could, except from the size, be hardly distinguished from those of *Am. Taylori.*

5. AMMONITES HYPHASIS, *Blanf.* Pl. X, fig. 2.

1863. Journ. As. Soc. Beng., p. 132, pl. 4, fig. 2.

1864. *Am. Seideli*, Oppel, Pal. Mitth. p. 283, pl. 80, fig. 3.

1865. *Am. umbo*, Blanford, in Strachey's Palæont. p. 78, pl. 17. fig. 2.

The transversally ovate whorls with their peculiar ribbings and the large umbilicus are very characteristic for this species. Sometimes the ribs are very sharp and interrupted on the middle of the back, or they are continuous up to a slight depression along with the sipho. Longer and shorter ribs are often alternating, and some of the former rise towards the edge of the back to sharply elongated tubercles, and divide from these each into two, usually three, or even four ribs. The ribs very seldom form slight elevations at the point where they are interrupted near the middle of the back. There is besides no certain regularity which of the principal ribs becomes tuberculated, sometimes it is in young specimens every second or third rib, but mostly the fourth, although the intermediate ribs are not of equal length.

In *Am. anceps* or *Am. coronatus* the lateral tubercles are by far more numerous and regular and are placed nearer to the edge of the umbilicus. On the whole the shape of the whorls of the Indian fossil is more allied to the former than to any other known European species.

Mr. Blanford's original figure of the species represents a specimen with unusually small tubercles, and even these are mostly broken away; the ribs are bipartite. The species can, no doubt, be only recognized with difficulty, and we have, therefore, preferred to give a new figure

on Plate X. There is certainly no mistake as regards the identity of *Am. Hyphasis* and *Am. umbo,* however different the figures of each may appear: of the former of which the originals are in the Asiatic Society's collection.

I do not think that I can be mistaken, in referring Prof. Oppel's *Am. Seideli* to the same species, the whorls in this last-named form are somewhat more compressed, but this is always the case with larger specimens, as we see on numerous fragments. *Am. Hyphasis* is not an uncommon species all through the Spiti shales, but usually only fragments are met with. Complete specimens of small size have been found at Gieumal and Kibber.

6. AMMONITES PARKINSONI, *Sow.*

1821. Min. Conchology, pl. 307. id. *Zieten, Römer, D'Orbigny, Quenstedt, Chapuis,* and others.

1863. *Am. Wallichii,* Blanford, in Jour. As. Soc. Beng., p. 127, pl. 1, fig. 4, and pl. 3, figs. 2-3.

1864. *Am Mörikeanus, Oppel,* Pal. Mitth. p. 281, pl. 80, fig. 2.

1865. *Am. Wallichii,* Gray. Blanford in Strachey's Palæont. p. 84, pl. 15, fig. 1, and pl. 19, figs. 1-2.

I tried hard to retain the Indian fossil, which was already described under so many different names, as a distinct species, but all my endeavours failed, and I fully believe now that there is not a single character which could be in any way satisfactorily used as a specific distinction. Most of the Indian specimens, which I have examined, belong to Quenstedt's variety *Am. Park. planulatus,* (Ceph. Deutsch. p. 143, pl. 11, figs. 2-3), having the habitus of a *Planulate* ammonite; not a single specimen of the inflated variety has as yet been found anywhere in the Himalayas.

The ribs bifurcate in our specimens generally about the middle of the sides, as usually in the Württemberg specimens, while those from the inferior oolite of Sully have the bipartition nearer to the back. Of the tubercles, which are often well marked at the bifurcations of the ribs, there are only slight indications in our specimens.

On the back itself the ribs are sometimes not so much bent forward as in European specimens, but they are always interrupted in the middle, their terminations being either opposite to each other or

alternate. The divisions of the sutures are quite identical, even in the details of the size of the different branches. The lobes are tri-,the saddles bi-,partite ; of the first lateral saddle the outer (*i. e.* near the back) branch is somewhat shorter than the inner, this being again bipartite. I observe the same peculiarity on several of the specimens which we possess from Sully in France. The German specimens are, as I said, especially like the Indian; and there does not seem to me to be any necessity, nor is there any conchological or palæontological reason, which could justify a new name for the Indian fossil. It is, we are well aware, an important question, how and where to put a limit to variation, but it is, on the other hand, worse to attribute a specific value to differences which are only accidental, and variable in one and the same specimen.

Am. Parkinsoni is not uncommon near Gieumal and Kibber; it occurs in the Spiti shales in Ngari and North of the Niti pass as well. The beds with *Am. Parkinsoni* are known through all the jurassic deposits of Europe. I quote Gray's name of *Am. Wallichii* as a synonym only on Mr. Blanford's authority: Mr. Blanford tells me, that he compared the originals in the British Museum.

7. AMMONITES THEODORII, *Oppel.* Pl. IX, fig. 4.

1864. Pal. Mittheilungen, p. 280, pl. 78, fig. 3. (and fig. 2 ?) !

1865. *Am. Griffithii,* in Strachey's Palæont. p. 86, pl. 20, fig. 1.—non *Am. Griffithii,* Sharpe.

The characters of *Am. Theodorii* lie in the compression and small involution of the whorls, and in the lateral flexuous ribs, which rise from a tubercle on the edge of the umbilicus in bundles of three or four and terminate on the edge of the back each with a smaller tubercle. In the course of further growth the umbilical tubercles become either obliterate, or sometimes retain their strength. The dorsal tubercles are partly opposite partly alternate, and in large specimens they join with each other by short ribs across the back. Some of the ribs remain single, but occasionally they divide on the middle of the sides, except in old grown specimens.

The lobes are trifid, and the first lateral is longer than the dorsal lobe. The saddles are bipartite, the dorsal being the largest, then

follow two lateral and two or three obliquely descending auxiliary saddles, placed on the umbilical wall. As Prof Oppel (loc. cit.) remarks, that there exists in young specimens of *Am. Theodorii* a row of tubercles at the edge of the umbilicus, it is difficult to understand how fig. 2 (loc. cit.) ought not to belong to the same species, but to *Am. Spitiensis* (*Cautleyi*, Opp.). We have, therefore, preferred to give a figure of a small specimen, although Prof. Oppel refers to pl. 83, on which another representation of the Ammonite is to be published. Prof. Oppel has, however, kindly communicated to me, that he will stop for the present his publication of the Himalayan fossils, until my memoir is ready. The resemblance of *Am. Theodorii* to European forms, as *Am. Jason*, *ornatus* and *Duncani* is worth notice, especially when a larger material for the study of the Indian fossil shall have been procured. On the first whorls there seems to be an indication of a row of tubercles on the sides of the whorls; this row is placed, however, nearer to the back, where the ribs bend somewhat forward, and not on the middle, or near the umbilicus, as is usually the case in the above quoted allied species. In the form of the shell the kind of ribbing and the partitions of the sutures, the compressed variety of *Am. ornatus* from the Württemberg Jura seems to be the nearest ally.

Am. Theodorii is a rare shell in Spiti; Prof. Oppel's specimens were collected in Ngari-Khorsum.

I cannot say much as regards *Am. Griffithii*, Strachey, Pal. p. 86, pl. 20, fig. 1. In its general appearance the shell does not differ much from *Ammonites Sabineanus*, Opp. Mr. Blanford tells me, that there exists undoubtedly a row of small tubercles on each of the dorsal keels, and that the representation of the specimen is not very correct. He believes it to be identical with *Am. Theodorii*, Oppel.

In any case the name must be avoided, as it was long since used by *D. Sharpe* for a cretaceous and quite distinct species, which, although itself identical with *Am. planulatus*, Sow., equally from the middle cretaceous strata, does not admit of any further use of the same name.

8. AMMONITES SABINEANUS, *Oppel.*

1864. Pal. Mittheilungen p. 288, pl. 82.

1865. *Am. jubar* in Strachey's Palæontology p. 82, pl. 20, fig. 2, and pl. 21, fig. 1.

Prof. Oppel's and Col. Strachey's figures of this species represent several of the principal and characteristic varieties, and I shall mention for the present only a few peculiarities, in addition to those which have been noticed already. Our material amounts to about 50 different specimens.

The form of the shell is always pretty constant: the whorls being compressed, obtuse at the back, with a gentle slope from the middle of the sides towards the umbilicus, in which about half of the height of the previous whorls is exposed. The ribs are flexuous, always somewhat bent forward, but otherwise subjected to very much variation. In the first stage of growth the ribs are very fine, filiform, either single or bipartite, from the middle of the sides. On the back they bend strongly forward, either continuous or interrupted in the middle.

The few flat tubercles along the edges of the back appear generally somewhat later, when the specimen has assumed a larger size. They are, as has been noticed by Oppel and Blanford, very variable in size and number. Sometimes several of the ribs increase considerably in thickness along the edge of the umbilicus, and at shorter or longer distances from each other.

In other specimens the lateral ribs are from the first beginning stronger, and they become gradually thicker with farther growth, as seen in both of Prof. Oppel's figures and in Col. Strachey's figure 2 on plate 20. The sutures are figured well by Prof. Oppel and Mr. Blanford; they consist of one dorsal and one lateral saddle, and the rest are obliquely descending towards the umbilicus, all being bipartite; the lobes are trifid, and the first lateral is the largest of all.

Am. tenuistriatus, Gray, (in Strachey's Palæont. p. 78, pl. 15, fig. 2 *a-c**) bears so many relations to the fine ribbed variety of

* Judging from the sutures of a similar fragment, fig. 2 *d.* of the same plate, would not be a bad representation of the sutures; this seems, however, to be a misprint as to the numbers and letter, inasmuch as Mr. Blanford, p. 78, states, "the sutures are not visible."

Am. Sabineanus, that it is not unlikely only a fragment of this, as represented by Gray. There are at least several similar fragments in our collection, which certainly do not belong to a separate species.

Mr. Blanford considers the *Am. tenuistriatus,* Gray, as being likely only a variety of *Am. Nepalensis,* Gray. It is certainly not identical with the species, which Mr. Blanford calls *Am. Nepalensis* in Asiatic Society's Journal of 1863; this last-named form is undoubtedly identical with *Am. macrocephalus,* Schloth., as will be found mentioned under the head of the latter species. Until Mr. Gray's original specimens have been very carefully examined and compared, the explanation of this and the other figures will always remain a point of difference of opinions.

9. AMMONITES SPITIENSIS, *Blanf.*

1863. *Am. Spitiensis* and *guttatus,* Blanford., Journ. As. Soc. Beng., p. 131, pl. 2, fig. 4, and pl. 4, fig. 1.

1864. *Am. Cautleyi, Stanleyi* and *Groteanus,* Oppel, Pal. Mitth. pp. 279, 282 and 283, pl. 78, fig. 1 (non fig. 2 ?) pl. 79, pl. 80, fig. 4.

1865. *Am. guttatus* and *scriptus,* Blanford, in Strachey's Palæont. p. 79, pl. 13, fig. 2, and p. 81, pl. 16, fig. 2.

It was not until after much hesitation and repeated comparison of large materials, that I was led to believe that all the names quoted above have been attributed to mere varieties of one and the same species. I would not like to impress this opinion upon any one who is obliged to derive descriptions from single specimens, or to judge only from the figures which have been given. Most of them seem to represent such different characters, that it is difficult to understand how the respective forms ought to have any connection at all.

The following are the characters common to all varieties :—

The involution extends to about half of the width of each whorl, the umbilical edge of which is provided with a row of transversely elongated tubercles; from these rise bundles of two, three, or four, ribs proceeding with a slight bending, either single or sometimes again bifurcating, towards the back. This is crossed by them with a strong curve forwards. On the middle of the back the ribs become often somewhat thinner, but except on the body whorl we have never ob-

served them quite obsolete. Two or three deep transverse furrows, marking the previous positions of the mouth, are visible in the circuit of one volution, they are always bounded posteriorly by stronger swellings, which are much bent forward, especially on the back. The sutures are divided into one dorsal, two lateral and two or three auxiliary lobes, (very seldom only one is visible). All the saddles are bit, the lobes tri-,fid. In the dorsal saddle the outer branch (towards the periphery) is invariably longer, in the first lateral it is usually the inner branch. The second lateral saddle is shorter and obliquely placed towards the first; it lies on, or very close to, the umbilical edge, while the two (or sometimes three) auxiliary saddles lie on the wall of the umbilicus.

The principal variation is in the thickness of the whorls. If it were possible to account for any other variable characters which would always accompany the former, we might be justified in distinguishing and characterizing one or two similar forms as quasi-species, but for this opinion I am unable to discover any support in our material. The section of the whorls varies with gradual alterations from round or broadly-ovate to oval in the direction of the height of each whorl. These alterations can be often traced to a certain extent on one and the same large specimen; however local varieties seem to be indicated, as for instance in Spiti the varieties with rounded whorls occur chiefly at Gieumal, and those with more compressed whorls near Kibber, at the other end of the jurassic ellipse. In Ngari both the varieties occur as well; and also North of the Niti pass, whence many specimens were brought down, in 1860, by Mr. F. R. Mallet. The number of tubercles on the umbilical edge varies from 15 to 22, it is, however, independent of the thickness of the whorls and sometimes greater, at other times smaller, in compressed specimens. The ribs are very constant as regards their direction; and their number in one bundle increases usually with the growth of the shell.

The height of the saddles is variable, and equally so the respective length of their branches, but their width is always greater than that of the lobes. Specimens with thicker whorls have the saddles often shorter, but this does not occur constantly, and besides it is well known that the height of the sutures generally decreases with the approach to the body-chamber.

A comparison of Prof. Oppel's *Am. Stanleyi* and *Groteanus* will, I believe, if the size be abstracted, leave no difficulty in their being recognized as the same species, and as identical respectively with Mr. Blanford's original *Am. Spitiensis*. Specimens from the same localities, as those of Messrs. Schlagintweit and Mr. Blanford's originals, being compared leave no doubt about this point.

Mr. Blanford's original figure of *Am. guttatus* represents a specimen* which stands intermediately between his *Am. Spitiensis* and Oppel's *Am. Cautleyi*. (Of the latter I refer merely to fig. 1, as I rather believe that fig. 2 represents a fragment of *Am. Theodorii*, Opp.). Mr. Blanford separated his *Am. guttatus* from *Am. Spitiensis* chiefly on account of the somewhat higher divisions of the sutures, and after referring to some slight differences in the ornamentation, he says (loc. cit. Journ., p. 131) " these latter differences I consider, however, to be unimportant, and should further specimens shew the sutures to be more variable than is usual in Ammonites of the same group, there would remain no good reason for distinguishing the two forms in question." Now I hardly need to notice anything more about the variations of the sutures than I have already stated. We possess from Kibber several specimens quite similar to *Am. Cautleyi*, Oppel, and I can only refer to my previous remarks as regards the alterations in the thickness of the whorls, to shew that we have most probably to deal only with a variety. Of course, if the compression of the whorls is to be accepted as a specific difference, then we have to grant immediately not only the independence of all the quoted synonyms, but we have to establish about half a dozen more of such temporary species. This is, we believe, not only not necessary, but in reality injurious even to the geologist. The figure of *Am. guttatus* in Strachey's Palæontology I can quote only on Mr. Blanford's authority as a synonym; nobody could recognize the species from this figure. Mr. Blanford says, p. 79. " the restoration herewith given on pl. 13, fig. 2 is consequently erroneous, the diameter of the whorls being probably at least half as much again," &c.

With regard to *Am. scriptus* (loc. cit.) there cannot be much doubt, that the fragment figured belongs to *Am. Spitiensis*, namely to one of the less compressed varieties. The outlines of the sutures shew

* It is deposited in the Asiatic Society's collection, Calcutta.

no difference, except that they are more deeply incised. We possess, however, specimens on which the partitions of the saddles go so far that some of them become laterally cut into two parts. Of European described forms, which are similar to the Indian fossil, there are especially two lately decribed by Prof. Oppel in his "Palæont. Mittheilungen, 1864, pl. 66, figs. 1 and 6. I would mention nominally only a Crimean species *Am. Theodosia,* described by Deshayes. 1838, in the Mem. Soc. Geol. de France, tom. III, pt. I, p. 32, pl. 5, figs. 23-24. This Ammonite resembles very much some of our compressed varieties, and a closer examination of the original specimens would be very desirable.

Am. Spitiensis is a common shell in the Spiti-shales, where they occur along the northern slopes of the Himalayas.

10. AMMONITES CURVICOSTA, *Oppel.*

1849. *Am. convolutus parabolis,* Quenst. Cephalop. Deutsch. p. 169, pl. 13, fig. 2.

1852. *Idem,* Kudernatsch in Abhandlg. d. k. k. Geol. Reichsanstalt, Vienna, vol. I, p. 14, pl. 3, figs. 7-10.

1858. *Am. curvicosta,* Oppel, Jura-formation, p. 555.

1864. *Idem,* Seebach, Hannoversche Jura, Berlin, p. 155.

We possess only one, but that a perfect specimen, which has been found at Chikkim in the Spiti shales. The tubercles near the periphery are only indicated, but the corresponding thickened ribs are distinctly expressed. The specimen agrees perfectly with those from Swinitza in the Banat, whence it was brought to notice by the late Kudernatsch. Oppel's designation of the form with a new name is, we believe, justified, and the species has nothing to do with *Am. Bakeriæ* or *Am. perarmatus,* Sow.

The species has for many years been well known from the brown Jura of Württemberg, Suabia, and other places in Germany. It has been lately noticed by Seebach from the beds of *Am. macrocephalus* at the Porta Westphalica in Hanover. We see it in Indian rocks occurring in the same beds; the species seems to be, however, much rarer than many others of the *Planulati* group.

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11. AMMONITES BRAIKENRIDGII, *Sow.* var.

1818. *Sowerby,* Min. Conch. vol. II, p. 187, pl. 184.

1849. *D'Orbigny,* Pal. Franç. Terr. Jur. I., p. 400, pl. 135, figs. 3-5.

1858. *Oppel,* Juraf. p. 377.

1863. *Am. torquatus,* Blanford, (*non* Sow.) Jour. As. Soc. Beng. p. 130, pl. 3, figs. 6-8.

1865. *id.* in Strachey's Palæont. p. 80.

Having compared specimens of *Am. Braikenridgii* from Bayeux with the Himalayan forms, we are unable to find any essential differences. The tubercles at the partitions of the ribs are only very seldom indicated in our specimens, but we see that quite similar variations exist among the specimens from Normandy. The species retains always the narrowness of its whorls, and the increase in the width of the section is very gradual. In large specimens of ours (about 100 mm.) the ribs become very thick. The indentations by the preceding whorls are always not considerable. The divisions of the sutures resemble much those of *Am. Humphriesianus,* as noticed by D'Orbigny. The lobes are tri-,the saddles bi-,partite, and of the branches of the dorsal saddle the outer (nearer to the back) is the longer, while on the first lateral saddle it is the inner branch. Quite similar divisions exist in compared specimens of *Am. Martinsii,* D'Orb., from Niort, and, besides the smaller width of the whorls of the latter species, I really do not see any specific difference. The deeper furrows, which marks the previous positions of the mouth, are the same in our specimens as in the Niort fossil. From specimens of *Am. Braikenridgii* from Bayeux, the single difference consists in the longer first lateral lobe, which in our Himalayan forms is invariably shorter than the dorsal lobe.

Localities. Common at Gieumal, rarer at Kibber, Longja and other places.

12. AMMONITES NIVALIS, *Stol.* Pl. X, fig. 1.

Am. testa discoidea, complanata; umbilico minimo; anfractibus lateraliter sublævigatis, ad peripheriam tuberculato-costulatis; dorso

obtuso. Suturis lateraliter quinque lobatis; lobo dorsali brevissimo, laterali primo maximo; lobis tri-,sellis bi-,partitis.

Proportions calculated from figured specimen (the diameter being taken as 1·00) in diameter of ...	·50 mm.
Outer whorl : whole diameter	0·52
Width of umbilicus : ditto	0·16
Width of the section : height	0·53

A discoid shell with involute whorls, so involute that only a very small portion of the inner volutions are visible in the narrow umbilicus. The greatest thickness of the whorls is near the middle of the sides, on which only striæ of growth are distinctly visible. On the edge of the somewhat roundish back there are numerous short costæ, which very soon disappear towards the umbilicus. The edge of the umbilicus is rounded and its walls are perpendicular. The sutures are divided similarly to those of species of the *Dentati* group. All the saddles are bipartite, gradually decreasing in size towards the umbilicus; the dorsal lobe is the shortest and the first lateral the longest; all the lateral lobes are tripartite, but not nearly so fine and filiform as in *Am. acucinctus.*

Locality: Kibber in Spiti; the figured specimen was found in 1861 by W. Theobald, Esq., Jun.

13. AMMONITES LIPARUS, *Oppel,* 1864. Pal. Mitth. p. 220, pl. 59, fig. 1.

The species is well known from the upper beds of the middle jurassic strata of Germany. Zieten's figure *Am. inflatus,* (pl. 1, fig. 5) is insufficient, but Quenstedt's representation appears to be characteristic.

There can be no doubt, that our Himalayan form agrees perfectly with Oppel's figure and description of the species. All the fine transverse striæ of growth and the divisions of the sutures are perfectly identical. Prof. Oppel forms another species, *Am. circumspinosus,* (ibid. p. 222), with which *Am. inflatus-macrocephalus,* Quenstedt. (Ceph. pl. 16, fig. 14, and Jura pl. 75, fig. 8) ought to be identical. It is no doubt difficult to form an entirely satisfactory opinion from figures alone, however it is certain that Quenstedt's figure of *Am. inflatus-macrocephalus* in his Cephalopoden, pl. 16,

fig. 14, does not shew any difference from Prof. Oppel's figure of *Am. liparus;* the former is evidently a cast and exhibits therefore the umbilical tubercles very slightly. The lobes are exactly the same.

Finally, I would still draw attention to *Am. Altenensis,* D'Orb. (Pal. Franç. Jur. pl. 204), from which Prof. Oppel has distinguished his *Am. liparus* and *circumspinosus.* There can be no doubt that from the existing figures the species might be kept separately, but we must remember that in *Am. Altenensis* the tubercles on the edge of the umbilicus become also a little farther distant from the edge, and that if they cease in *Am. liparus* to project upon the space of the umbilicus, we are at a loss for any reason for separating these two (the French and German) species.

Locality. In the Spiti shales near Kibber ; rare.

14. AMMONITES TRIPLICATUS, *Sow.* 1821, Min. Conch. Vol. III, p. 167, pl. 292.

Morris in his Catalogue (p. 295) quotes the species from the Kimmeridgian. Roemer, Quenstedt, (Ceph. pl. 13, fig. 7), and others have identified the German middle-jurassic species with the English. Oppel (Jura-formation p. 550) proposed a new name for the German forms, (*Am. funatus* ; *vide* also *Seebach's* Hannov. Jura. p. 155), without any critical ground whatever, simply because he says that Sowerby's species belongs to the upper Jura. We cannot at present go so far as to account for all the numerous variations of the species, which have been noticed by several observers previously. The species is always thin ribbed in the first stage of growth, but the whorls are either thicker or more compressed. The ribs are always curved from the umbilicus towards the periphery. Large specimens have the last whorls always somewhat compressed and usually higher than broad. The ribs divide here often into four instead of three. Kudernatsch noticed several of the most marked varieties from the Banat, and we would refer here to his description in the first volume of the Abhandlungen der k. k. Geol. Reichsanstalt, Wien, 1852, p. 15, pl. 4.

Certain it is, that the numerous Himalayan specimens are quite identical with those from the Brown-Jura near Locken in Württemberg

and those from Swinitza in the Banat. From what I know of the English *Am. triplicatus,* I cannot see any good reason to justify the separation of these forms into species. Until more decisive proof is given, we do not think it advisable to accept the *Am. funatus.*

Am. triplicatus is very common all through the jurassic shales of Spiti, we have it represented in about 60 specimens in different stages of growth, and of great variation. Col. Strachey found it not less numerous North of Kumaon in Ngari Khorsum and at Niti.

15. AMMONITES BIPLEX, *Sow.* 1821, Min. Conch. Vol. III., p. 186, pl. 293, figs. 1-2.

There is no possibility of distinguishing specifically between the specimens of this species from *Aylesbury* and those from the *Himalayas.* The ribs never become tripartite, (even in our specimens of 200 mm.), except occasionally near the transverse furrows, which indicate previous stages of the mouth. The whorls increase very little in height, and are often flattened on the sides. It is nearly impossible to distinguish between young specimens of *Am. biplex* and *Am. triplicatus,* the ribs are in both equally fine and bipartite, but they seem to be always more bent forward in the latter species.

It would be hardly possible to go through all the forms which have been, in Germany, by different authors and at different times, attributed to Sowerby's *Am. biplex,* but, I believe, that there are very few English palæontologists or geologists to whom Sowerby's meaning of *Am. biplex* was and is unknown. *M. Seebach* (Hannoversche Jura, 1864, p. 157) proposes for it the name *Am. Kimmeridgiensis,* and says (loc. cit., p. 156) that it appears to be best to abolish the name *Am. biplex,* Sow., altogether. This is certainly a novel proceeding! If we first knew the meaning of all the species which have been in Germany mistaken for *Am. biplex,* Sow., we might be justified in proposing and correcting others, but the matter is by no means settled by proposing a new name. By far the greatest confusion exists among the German forms.

The specimen figured by Mr. Blanford as *Am. biplex* in the Jour. As. Soc. Bengal, 1863, pl. III. fig. 4, is not *Am. biplex,* but a thin-ribbed variety of *Am. triplicatus.* The figures 1 on pl. 11 and 12 in Strachey's Palæontology are correct.

Am. biplex, Sow. (as identical with the English Kimmeridgian species) is, although not so common as *Am. triplicatus*, still plentifully to be found everywhere in the Spiti shales, and is usually the associate of the last-named species.

16. AMMONITES ALATUS, *Strachey.*

1865, in Palæontology loc. cit. p. 76, pl. 18, fig. 3.

The principal distinguishing character of this species, as has been already noticed by Mr. Blanford, is in the transverse elliptical section of the whorls being wider than high. The quoted figure "is compiled from two fragmentary external casts," as stated by Mr. Blanford, but unfortunately all the undulations of the transverse striæ have been left unnoticed, or they were perhaps not visible. In our specimens they are seen exactly like those of *Am. Eudesianus*, D'Orb., (Pal. Franç. Jur. p. 386, pl. 128), with which also the divisions of the sutures principally agree. The French species differs by a smaller number and more rapid increase of the thickness of the whorls. *Am. Adeloides*, Kudernatsch (in Abhandlg. d. k. k. Geol. Reichsanstalt, Wien I. 1852, p. 9, pl. II, figs. 14-16) cannot be much different from *Eudesianus*, and is probably a local variety only. *Am. Adelæ*, D'Orb. (loc. cit. p. 495, p. 183) cannot stand a close comparison either with *Am. Eudesianus*, or with the Indian fossil, if D'Orbigny's figure and description of the species is correct.

The nearest ally to the Himalayan species is, so far as I remember, a Fimbriate *Ammonite* which I have several years ago collected with my friend Prof. E. Suess at the village Wyeska near Puchow in the valley of the Waag river, in N. W. Hungary. We let it pass, I think, at that time for *Am. Adelæ*, and under the same name it is probably quoted by Dionys Stur in the "Jahrbuch" of the Geological Institute, Vol. XI, 1860, p. 42. A closer examination seems to me very desirable.

Am. alatus is a rare species in Spiti, I met only with one specimen North of Kibber.

17. ANISOCERAS GERARDIANUM, *Stol.* Pl. X, fig. 3.

A slightly curved fragment, somewhat spirally turned, ornamented with distant and very oblique ribs. These are a little weaker in crossing the ventral region, but not fully interrupted; along the sipho or the dorsal region there is also a slight impression visible

on the interruption of the ribs marked by small tubercles. The sutures consist only of four saddles and as many lobes : the former are all bipartite and nearly equal in size; of the lobes the dorsal is bi-,the other tri-,partite, the former is the deepest of all.

The tendency to a spiral involution, which cannot take place in one and the same plane, shews clearly that this and several other similar jurassic and cretaceous species cannot belong to *Ancyloceras*, to which they are usually attributed. The single specimen is the first of this genus known from the Himalayas; it is undoubtedly from the Spiti-shales, but the exact locality is not noticed; it was collected by Capt. Hutton.

18. BELEMNITES CANALICULATUS, *Schlotheim*, 1820.

Bel. sulcatus, Miller, *Bel. Altdorfensis*, Blainv. *Bel. Bessinus*, D'Orb., etc.

1863. *Bel. sulcatus*, Blanford, in Journ. As. Soc. Bengl., p. 125.

1864. *Bel. Gerardi*, Oppel, Pal. Mitth. p. 273 (?).

1865. *Bel. sulcatus*, Blanford in Strachey's Palæont. p. 76, pl. 10.

Mr. Blanford was, I believe, quite correct in referring the specimens (from the Spiti shales) in Dr. Gerard's and Col. Strachey's collections to the above-named species. There is no possibility of distinguishing them (except their usual large size) from the English, French, or German specimens of the same species from the Oolite.

We do not possess very good specimens from the Oolite* of Cutch, but the fragments do not exhibit any difference from the Himalayan, and I believe Sowerby's determination (in Trans. Geol. Soc. V. pl. XXII, figs. 2-3) was a correct one.

It is probably for this species, that Prof. Oppel has lately proposed the name *Bel. Gerardi;* I cannot at least think what other "*Canaliculate*" it could be. Everest's figure (Asiat. Res. XVIII. pl. I. f 17) to which Dr. Oppel refers, represents no doubt this species; the originals are in the Asiatic Society's collection.

Localities. The species is to be met with in the Spiti shales, wherever they occur. Large alveoli of 6 inches in length are not

* Many Cutch fossils, which I have lately seen, are identical with species from Bayeux; such as *Trochus duplicatus*, *Opis similis*, etc.

uncommon, and with these, guards the thickness of which exceeds sometimes one inch.

Bel. canaliculatus can be collected at many places in Spiti on the boundary of the shales and the Tagling limestone loose, with the three species which I have described from the Lias. I am here at a loss to determine, whether the species really occurs in the limestone. I do not see any impossibility, that it may have existed previously to the deposit of the shales, but I have no certain evidence, as all my endeavors to trace a specimen in the limestone itself failed. Moreover I found South-west of Chikkim, with the three previously described species, many specimens of true *Bel. canaliculatus.* One of these had a portion of the alveole preserved. In breaking this specimen I found the rock to be identical with that of the shales, and not with the limestone. This confirmed me in the belief that the *Bel. canaliculatus* is only washed out from the Spiti shales, and the species of the lower and upper beds are found together at present only in consequence of accidental mixture. We must accept this to be the real case, until we can prove the occurrence of the *Bel. canaliculatus* in the limestone itself, of which I do not see, as I mentioned before, any impossibility. The Spiti shales overlie Tagling limestone in most places without any intermediate beds, and this is in favor of either of these opinions.

19. BELEMNITES CLAVATUS, *Blainv.* (*vide* D'Orb. Pal. Franç. Jur. I., p. 103).

One well preserved specimen was found by myself in the Spiti shales near Longja. It is the only one I have seen from any part of India, and compared with French and German liassic species there is no possibility of finding the slightest difference. I will not say that more and larger specimens may not show some differences from the liassic types; however, Prof. Oppel (Juraf. p. 153) remarks, that similar forms extend to the lower oolite, but that they may possibly be separated from the true *Bel. clavatus.* On the other hand I wish not to assert, that the Belemnite occurs originally in the Spiti shales, it may have been washed out in the same way as was certainly the case with other species. But just at this locality the lower Tagling limestone is more than a mile off.

Section 7.—Upper jurassic beds.—Gieumal Sandstone.

On the Spiti shales rests a sandstone formation, which, from its usually light colours, forms a great contrast to the lower beds. Its thickness varies from two to about 600 feet, which it seldom exceeds. The principal mineralogical character of this sandstone is its siliceous element, which is in some beds so very prevalent that it is not easy to distinguish fragments of it from the carboniferous quartzites, which occur down below in the Spiti valley in the same vertical series of rocks. In some beds the sandstone forms a rather loose grit, or it is even coarsely conglomeratic. The colour is light yellowish. Somewhat darker beds are not uncommon, generally strongly carbonaceous and more compact. These calcareous beds are especially the seat of a great number of fossils, of which an *Opis*, one species of Oyster like the *Ostrea gregaria*, and *Avicula echinata* are very common, occurring associated in the same way as they do in the European jurassic beds; for instance at Nattheim. The Gieumal sandstone retains this character very constantly all through Spiti. Its extension is limited by the Spiti shales, and I have not observed it any where beyond the jurassic ellipse. South-west of Gieumal the lowest beds are seen partly interstratified at contact with the uppermost beds of the Spiti shales; this proves distinctly their close connection with these shales, although mineralogically they are quite different. The interstratification must be explained by undulations of the jurassic ground at the close of the deposit of the shales and in the beginning of that of the sandstone deposit. By far the greatest portion of the

sandstone rests conformably on the shales, and from the remarkable features which it presents it is necessary to distinguish it as a separate group. This *Gieumal sandstone* (called after the village Gieumal) occurs in the very same relative position, and of a perfectly similar mineralogical character, to the North of the Niti pass and in Ngari Khorsum. There is no doubt, that it has a further geographical extension, but subsequent researches have to determine what connection these widely separated deposits have with each other.

FOSSILS OF THE GIEUMAL SANDSTONE.

The following fossils have been observed near Gieumal, the same are to be met with, as has been stated, in several other places where the Gieumal sandstone occurs, but they are usually not so well preserved as to admit of satisfactory determination.

1. OSTREA, *sp.*, resembling the *Ost. gregaria*, Sow., of the Coral-rag; another species resembles *O. Sowerbii.*

2. GRYPHÆA, *sp.*, a coarsely ribbed species, with very thick shell, seems to be new; it is especially common at Chikkim station.

3. AVICULA ECHINATA, *Sow.* (Min. Conch. pl. 243.) The researches of the last few years all agree in the point, that *A. echinata* and *Bramburiensis*, Sow., are the same, and identical with *A. tegulata* and *decussata* of Goldfuss. I may say, that our specimens from the Himalayas are certainly identical with the original *A. Bramburiensis*, Phill. (*vide* Morris and Lycett). There seems no reason to separate the species from *A. echinata*, Sow., of which Morris and Lycett (p. 16) say, that the vertical range is very considerable. Morris in his Catalogue, p. 163, quotes it even down to the Lias.

None of our specimens shew the unequal ribbings, as represented in Goldfuss' *A. tegulata* or *decussata*, and they agree, therefore, much better with the English forms. It is evident that several questions about this interesting species are not yet settled. Our Himalayan specimens agree best with the Cornbrash species. Mr. Blanford

quotes it under the same name in Journ. As. Soc. Beng., 1863, p. 137.

4. MYTILUS MYTILOIDEA, *Blanf.* (Journ. As. Soc. Beng., 1863, p. 137, pl. IV, fig. 8, non *M. mytiloides*, Lam.) occurs with *Avicula echinata.* I have not seen any better specimens than that figured by Mr. Blanford. The anterior or lunular portion of the shell is somewhat concave and elongated-elliptical in shape. The species resembles very much *Mytilus tumidus*, Mor. and Lyc., (Great Ool. Foss. pt. II, p. 37, pl. IV., fig. 5) of the Great Oolite of *Minchinhampton Common*, and may be probably identical with it.

5. LIMA, *sp.*, a large species with concentric, lamellar striæ of growth only, much inflated; apparently new.

6. AMUSIUM DEMISSUM, *Bean*, (Pecten id. Geol. Yorksh. I, pl. 6, fig. 5). We possess only one specimen, this is, however, perfectly like Prof. Phillips' or Goldfuss' figures, and evidently the same which Rœmer figures as *Pect. vitreus* (Ool. pl. 13, fig. 7). D'Orbigny describes the species from the Russian jurassic deposits in Murchison's Russia p. 475, pl. 41, figs. 16-19. An interesting fact has been recorded (Zeitsch. d. Deutsch. Geol. Gesellsch. 1861. XIII, p. 400) by Mr. Trautschold as regards the difference in the ornamentation of the two valves in some species of *Pecten* (*Amusium*), namely, one of the valves having only concentric striæ of growth and the other radiating ribs. This may serve as a hint how very cautious we ought to be in naming new species.

7. PECTEN BIFRONS, *Salter, in parte* (Strach. Pal. pl. 22., fig. 5).

It is hardly necessary to say anything more than has been already stated on page 74. I do not know any European species which could confidently be identified with ours; but there are many described by *Goldfuss*, *Quenstedt* and *Buvignier*, which are closely allied.

8. ANATINA SPITIENSIS, *Stol.* Pl. X., fig. 4.

An. testa elliptice-elongata, transversa; subconvexa, inæquilaterali, antice parum prolongata, rotundata, postice maxime producta, caudata, subarcuata; superficie striis concentricis ornata postice radiatim obsolete punctata; musculi impressione anteriori rotundata, ad dentem marginis cardinalis approximata; posteriori ovata, impressione auxiliari multo minore superposita; pallio integro.

Shell ovate elongated, with the greatest elevation along the caudate posterior extremity from which the shell slopes very gradually to the lower margin; the anterior side is very short and rounded. The hinge is prominent, and the cardinal process very strong. The anterior muscular impression is rounded, the posterior somewhat elliptical, with another small impression above it. The palleal impression is entire, except a scarcely marked sinuosity, which it forms in crossing the ridge of the greatest convexity near the posterior muscle. The surface is covered with striæ of growth; only on a small portion near the posterior extremity a radiating punctuation is visible.

There is only one species, which seems to be like the Indian fossil *An. Bellona*, D'Orb. (Prod. I, p. 336) from the Callovien; but nobody can imagine what species D'Orbigny means to indicate by the few words which he had added to the name.

An. Spitiensis is a rare fossil, I have observed it only near Gieumal.

9. ANATINA, *nov. sp.* Another far more elongated species from the same locality; the anterior part measures about two-thirds of the posterior, so that the umbones are nearer to the middle. The surface seems to exhibit only striæ and sulci of growth. I am not aware of any European ally, but a full description must be deferred until better specimens can be procured.

10. OPIS, *sp.* Judging from a great number of casts the Himalayan fossil seems very like to *Opis Moreana*, Buvignier, but it has been as yet impossible to procure even one good specimen with the shell.

Section 8.—Cretaceous rocks.—Chikkim limestone.

At a few places within the extent of the jurassic ellipse there is a white limestone to be noticed, the stratigraphical position of which as regards the lower strata is very clear; it covers the tops of only a few hills.

The limestone, although on the weathered surface often purely white, is on a fresh fracture either somewhat blucish or greyish white, and if perfectly compact not bituminous; there are, however, strata which are somewhat earthy, and these give a strongly bituminous odour if struck with the hammer. I have traced these limestones only at three localities in Spiti.

On the top of the sandstone hill, South-west of Gieumal, there is a small portion of it at a height of about 16,500 feet. Its thickness hardly exceeds 100 feet, and the whole extent which, no doubt, has been once much larger, is only about 1,000 feet in length and about 200 feet in width. Above the small village *Tshissigaoǹ*, somewhat near 16,000 feet, there is another portion of this limestone, it is here compact like that at the former locality, and isolated in three or four patches. The greatest thickness of this limestone, amounting to about 500 or 600 feet, rests on the sandstone of the Chikkim hill, near the village of the same name. It rises to an elevation above the sea of more than 16,000 feet. Its mineralogical character is the same as previously mentioned. The whitish color of the rock is so characteristic, that it can be instantly recognized from the yellowish colored *Gieumal sandstone* below it.

Not a trace of a fossil has been noticed at any of the other localities, except on the Chikkim station, where the age of the rock has been put beyond doubt. Several fragments of shells of *Rudistes* and numerous *Foraminifera* have been observed. The latter could be traced only on the weathered surface of the rock, and they belong all to genera which are represented in the cretaceous strata. It would be useless to undertake to name and describe new species, as they are, from their state of preservation, far too imperfect for that purpose. I shall, however, refer to some similar forms, from which an idea may be formed as to their character.

1. NODOSARIA, 2 *sp.*; shorter with thicker joints, resembling *N.*

intercostata, Reuss; and a longer species (up to and above 1 inch), very much like and, I should say, identical with *N. Zippei*, Reuss, from the Plæner of Bohemia.

2. DENTALINA *conf.* ANNULATA, *Reuss.*

3. ROTALIA, *sp.*

4. TEXTILARIA, 2 *sp.*; a slender one resembling *Text. anceps*, Reuss, and another much broader species.

5. HAPLOPHRAGMIUM, very like *H. irregulare*, Römer, sp.

6. CRISTELLARIA, *sp.*

The most common of these *Foraminifera* are one or perhaps two species of *Rotalia*, the *Textilariæ* and the *Haplophragmium*.

Section 9.—*Cretaceous.*—*Chikkim shales.*

Looking towards the Chikkim station from Kibber there is a change to be noticed in the colour of the top-beds, which appear somewhat dark yellowish as compared with the rest of the limestone. On examination of the spot a grey or darkish marly shale is to be found, in places very earthy. The whole thickness is not more than 200 feet, and probably even less. I have not been able to discover even a trace of any kind of fossil, nor have I seen these beds on any other spot in Spiti. From the great similarity of these shales to the limestone, especially at their contact, I am much inclined to believe that these marly shales are closely connected with the limestone and also of *cretaceous age*; but a satisfactory determination of these strata can be obtained only by the discovery of fossils, as there are no other beds above them from which their relative age could be even guessed.

CHAPTER IV.—*River and Lacustrine deposits.*
(Karéwah deposits of Capt. Godwin Austen.)

After the last marine deposits in Spiti—*the Chikkim shales*—an immense period followed during which the atmospherical (meteorological) waters have been labouring to change, disfigure, and to destroy what a far longer lapse of time had endeavoured to erect; I mean principally the action of the rivers in the formation of valleys and deeply-cut ravines. There can be no doubt, that the present depth of the valleys has been attained only in the course of time, and that the rivers did flow at a far higher elevation than they do at present. I observed opposite Shalkar, on the left bank of the Spiti river, flat and rounded pebbles of the red quartzitic sandstones of the *Muth series*, and of the greenish sandstones of the *Bhabeh series* at an elevation of about 1,500 feet above the present level of the river-bed. It is evident that these could come only from the Pin valley, or from any of the western ravines further to North. From the Para valley or the Ghu stream not a single pebble of this description is brought down. This is, so far as I know, the highest point of the occurrence of rounded pebbles in Spiti, although they may be possibly traced still higher. Above and round Shalkar and near the mouth of the Para and Ghu rivers there have to be noticed extensive beds of a fine yellowish clay, it is in places hardened by calcareous matter to a compact marly stone. Generally no clear stratification is perceptible, however sometimes the clay occurs laminated or even at a few places, as a little South of Shalkar, in thin beds. These clay

deposits are to be found throughout the Spiti valley, but usually at a higher level and in those parts of the valley which are much broader than others. We can, from this, justly suppose that these places were, by the widening of the waters and in consequence their decreasing velocity, more fit for the deposits of the finer materials which have been brought down from all sides by the glacier streams. I have spent hours in search after any kind of organic remains in these clays, and have, to my great distress, not found even a trace of a shell either in the neighborhood of Shalkar, or on the Para river, or in any other part of Spiti, as for instance below Drangkhar. Dr. Thomson (Travels, p. 117) mentions from a sandy bed near Kyuri (Kuri) a *Lymnea* and a *Planorbis.* The *Lymnea* is still living in great quantities in small tanks near Shalkar and Thabo, and at a higher elevation in a stream near Drangkhar, being much smaller at this last locality than at the others.

I am not aware of any living *Planorbis* in Spiti, but I procured a few small *Helices*, *Pupa* and *Nanina.* All these shells have been previously noticed by W. Theobald, Esq., Jun., in his notes, etc. (Journ. As. Soc. Beng., 1862, pp. 509 and 520.) Great numbers of shells have been discovered by Dr. Thomson on his travels in the North-west Himalayas, and also by Genl. A. Cunningham, and lately by Capt. Godwin Austen.

The large alluvial plateaux on the river banks, chiefly consisting of boulders of different rocks, are generally not more elevated than about 400 feet above the present level of the river. They are found all through the course of the valley, especially along the Spiti river in its wider portions. They are either loosely adherent or hardened to a kind of conglomerate. These deposits are seen sometimes in several terraces one above the other; the greatest number which I observed was five, and often the second one from above was the most extensive, but this differs according to the locality.

The large blocks, which occur in the alluvial deposit, are the cause of peculiar columns, which resemble the glacier tables and erratic blocks. The finer materials round a block are constantly washed away, while those below the block are protected from the direct action of the atmospheric waters. In this way all the different fantastic pinnacles of Dr. Gerard and other travellers have been and are still being formed. For more particulars I would refer to Capt. Godwin Austen's notes in the Quart. Jour. Geol. Soc. Lond., 1859, XV, p. 224, where a few representations of the principal features of similar deposits are given. Besides the direct action of the waters the great accumulations of debris must be attributed to large snow beds, which seem to have been, at least partly, the cause of extensive slips of mountain sides. Calcareous waters have occasionally with their solutions cemented these accumulations to a perfectly hard rock, as is to be found in places round Drangkhar. This town is built on ground which seems to be an immense slip of the western portion of the adjoining mountain. It seems to have resulted from the combined action of the flowing waters below and probably great masses of snows above.

PART II.—GEOLOGICAL FORMATIONS IN RUPSHU.

Sections in Rupshu.

The section across the province Rupshu is represented in Fig. 3, Pl. II.' it leads from South to North-east by north, from the Spiti boundary on the Parang pass to the village Sungdo on the Indus. The southern part of Rupshu belongs stratigraphically to the large secondary basin of Spiti, and we find, with very slight alterations, a repetition of all the older formations which have been previously described. The middle and northern parts of Rupshu are occupied by metamorphic and gneissose rocks, and then follow, after a slight interruption, Serpentine rocks, and unaltered, greenish and reddish, stratified rocks. To avoid many repetitions of what has been previously stated on the one side, and on the other not knowing this portion of the country to the same extent as the southern, I believe it will best answer all required purposes to state briefly the formations in the same order as they are followed in the section from South to North. When I have been able to obtain more extensive information from the northern parts of Ladak, I shall endeavour to give a more satisfactory account of the geological features of that country: for the present the section may give an idea of what is to be expected, and how much is still to be done.

CHAPTER V.—*Secondary formations in Rupshu.*

1. Upper Tagling limestone.

Starting from the southern frontier of Rupshu we met the upper Tagling limestone on the top of the Parang pass, as previously described, with characteristic fossils of the middle liassic strata of the European Alps. In

descending down from the Parang pass not much can be said from direct observations. The greatest portion of the descent is covered with a large glacier or extensive snow-beds. Besides the weather was, as usually, too unfavorable to permit any examination of even the loose blocks which were lying all round. On the Tagling pass the whole ridge of the Bara-Latse range consists of the Upper Tagling limestone, and *Belemnites* are sometimes to be met with.

The Parang glacier descends on the northern side to something less than 17,000 feet, and opposite to its termination the secondary limestones are seen in great contortions pressed against greenish sandstones and white quartzite, probably of carboniferous age. In proceeding down the Para valley very extensive accumulations of debris occur on both sides of it; and it is sometimes impossible to ascertain what rock is *in situ* and what has been brought down by the river, or rolled from the sides of the valley. As it is hardly to be expected that a traveller could climb up every lateral ravine or mountain side, the examination of the rocks is a little doubtful in places, and I would by no means insist upon the boundaries marked in my section, as being *absolutely* correct. These have been defined more from the distinction of the strata, as they are represented on the large scale. Due attention has been of course paid to the debris, especially when it contained any fossils, and it has always been attempted to ascertain the original site of the blocks. As has been previously stated, the carboniferous rocks appear in dome-form under the limestones South and North of the Parang pass, and with these strata all those above have been more or less affected by the disturbance. We passed over debris of rocks of very different description, and often met blocks of upper Tagling limestone with the characteristic Gastropoda, until we reached the camp Tatang-yogma.

2. Lower Tagling limestone.

A few hundred yards North of this camp the lower Tagling limestone is found *in situ*. It is again chiefly a brown oolitic or somewhat arenaceous limestone, weathering of a rusty brown on the surface, and in some places containing numbers of fossils. We met here with a band of the limestone, which almost exclusively consisted of *Terebratula gregaria.* Of other fossils have been noticed *Terebratula pyriformis, Rhynchonella Austriaca* and *variabilis,* and besides a few fragments, a little specimen of an *Ammonite,* resembling *A. macrocephalus. Bel. bisulcatus,* n. sp., is not very common, and it is difficult to obtain good specimens. The beds in which these fossils occur dip at an angle of only about 20° to south-west, and continue so still farther to the north. Taking the Tagling limestone, on the whole, we do not think we under-estimate its thickness at about 2,000 feet, of which somewhat less than the half may belong to the lower and the rest to the upper beds.

3.—Para limestone.—Rhætic.

A few miles North of the camp Tatang-yogma a considerable change in the character of the rock takes place. We come upon the blue earthy and strongly bituminous limestone, which is characterised by *Megalodon triqueter* and *Dicerocardium Himalayense,* and which I have previously described under the name of Para limestones. *Neoschizodus, Isocardia,* a few small *Gastropoda,* and occasionally some *Lithodendron-like corals* are to be met with, but nothing in such a satisfactory state of preservation as to admit of specific determination. The *Megalodon* and *Dicerocardium* are very characteristic for this series of limestone, the large cordiform sections of their thick white shells make them very easily perceptible even to an inexperienced eye. The dip of the Para limestone, the thickness of which I would estimate between 1,200 and 1,500 feet, is chiefly to south-west varying between 20 and 50 degrees. Disturbances and contortions

occur, but they are not very considerable and are more local. I have already mentioned that the thickness of the Para limestone decreases considerably towards the south, and that it seems to thin out altogether in the southern and south-western parts of the Spiti valley. Its geographical extent is no doubt by far greater in Rupshu than in Spiti.

The Para limestone, which we have previously referred to the Rhætic formation, extends to the north as far as a few miles south of the camping ground "Palang-balda."* Before reaching—on our descent in the Para valley—the Palang-chu, a large tributary of the Para river from the south-east, we come, below the characteristic Para limestone, upon a white band of compact limestone, conformably underlying the former, although partly much disturbed. I have not observed any other fossils in it than great numbers of *Corals*, and occasionally some small *Gastropoda*. I can hardly imagine, that we could have anything else than triassic limestone of the Lilang series below the Rhætic formation. The question is more doubtful, whether this white band of limestone ought to be referred to the former or to the next series. The more common occurrence of similar Lithodendron-like Corals in the limestones below the Rhætic beds proper seems rather to indicate their assignation to the lower, or the triassic series.

White band of limestone.

Again a great thickness of limestone follows in proceeding farther to the north. I have not succeeded in tracing here any fossils in it except Corals. From the very great similarity with the triassic limestone in Spiti, and from its stratigraphical position, I have no hesitation in attributing this

4.—Lilang limestone. —Trias.

* I must remark here, that the section in Fig. 3 is taken a little to the West of the Para valley, proper, to which our observations have been chiefly confined. However, there can be, no doubt, such a slight difference if any, from the section which I am describing in following the course of the Para river, that it is of no consequence whatever for the general idea of the geological structure, and a change would only complicate the representation.

limestone to the Lilang series. The limestone varies considerably, as before described, in its color and composition. It is often grey or whitish and compact, or black and dolomitic or even shaly. These latter beds are very earthy, and exhibit in places a kind of bacillar structure, which seems to be the first effect of metamorphism noticed to the South of the great mass of metamorphic rocks which occupy the middle portions of Rupshu.

CHAPTER VI.—*Palæozoic deposits in Rupshu.*

5.—Kuling series.—Carboniferous.

Next below the Trias we have to mention beds, which can only correspond with the Kuling or carboniferous series. The beds are only a few hundred feet thick, and consist of greenish sandstones and shales, and light-colored quartzites. On the whole, these strata seem to be more affected by the metamorphosing forces than any of those previously mentioned. They are in places highly altered; the shales are micaceous, and exhibit throughout a distinct bacillar structure. I have not observed any fossils in these beds in the Para valley itself, but Capt. Godwin Austen tells me that he found some carboniferous Spirifers a little farther to North-west; this would be very close to the point where our section is drawn.

CHAPTER VII.—*Metamorphic schists, &c.*

Entering the Tsomoriri valley we come upon quite a different geological horizon.

6.—Metamorphic rocks.

At the mouth of the valley itself we have to the west still the sandstones and quartzites, which can be referred to the Kuling series, but on the eastern side are distinctly metamorphic rocks. These latter are the only ones which become visible on both sides of the valley, and extend far to North. In the section the width of the band of metamorphic rocks, including the gneissose and granitoid beds, amounts to nearly

24 miles from south-west to north-east. The strike of all the rocks is, as previously stated, from north-west to south-east, and the dip is principally to south-west throughout.

Chloritic and mica schists.—The metamorphic strata next below the carboniferous rocks consist chiefly of thin-bedded chloritic and micaceous schists, traversed by a great number of veins of pure white quartz. A short range of snow-covered mountains, which rise to about 21,000 feet, extends some distance to the north-west and terminates somewhat to north of the southern end of the Tsomoriri lake. This range consists of granitoid gneiss, coarsely stratified, in fragments representing good typical granite. The rock is peculiar from having the greater quantity of felspar of a pink *Orthoclas*, which we met here only for the second time on all our journey. The felspar and quartz are present nearly in equal quantities, and the mica is a dark brown or black Biotite. I have not observed any veins of Albite-granite in this gneiss, neither any other accessory minerals worthy of particular attention. To the North of this granitoid ridge we have again a series of thinner stratified beds. They are principally quartzose schists, containing some felspar and laminated Biotite of a grey graphitic colour; Muscovite is very subordinate and often wanting altogether. Through the felspar these schists, when occurring in somewhat thicker beds, pass very easily into gneiss.

Gneiss.

Quartzose schists.

True gneiss is again to be found in the neighbourhood of the small Gyagar lake (to the north of Tsomoriri). It is apparently very different from the former, South of Korzok. The quartz is white but more impure and sandy, the mica is the same Biotite, and besides smaller pieces of pure Felspar, there occur large crystals of Orthoclas which are very impure by admixture of white Albite and Mica. Veins of Albite-granite have equally not been observed here, but black Tourmalin is to be met with in quantities and often in large lumps.

Being rather thinly stratified, the gneiss passes on the other side with very gradual changes again into quartzose beds, which are only devoid of the large crystals of felspar, but still contain schorl in abundance. These quartzose schists form both sides of the Puga valley and become towards the Epidote rocks somewhat chloritic, and even garnetiferous, they dip against these Epidote rocks, where they are visible in the eastern part of the Puga valley.

The axis of Cunningham's *Trans-Himalaya* or *Tsomoriri range* consists here of a series of *Epidote, Diallage* and *Serpentine* rocks. From their dark colours these rocks have sometimes been referred to *basalts*, but they have certainly nothing to do with these more recent volcanic rocks. At first coming to the camp on Puga stream we met with an epidote rock, consisting of crystallized or granular masses of *Epidote, Quartz* and *Albite*. The epidote when crystallized occurs in short prisms of yellowish or bright green colour.

Epidote rock.

It is often replaced by *Diallage* occurring in the same manner in short laminar prisms and forming a beautiful *Syenite-like* rock. Somewhat farther to North the Epidote disappears altogether, and the *Diallage* is often found disseminated through a dark green serpentine mass, and in this way forming a very peculiar rock which by many geologists, especially in the Apennines and Southern Alps, would be called *Gabbro;* the Himalayan agrees exactly with the Alpine rock. *Diallage* occurs besides in large lumps, and very seldom is any *Bronzite* to be seen here. The Serpentine rock contains also sometimes sparingly zeolitic and felspathic minerals, and varies greatly in colour. Farther to East it is occasionally to be found as Serpentine-schist and purer in thin veins. In the Puga valley itself no stratification whatever is perceptible in the whole series of these last-mentioned rocks; they have a truly massive structure.

Diallage rock.

Gabbro.

What is still remarkable and perhaps worthy of notice are large spheroidal masses of quartz, which, in addition to numerous quartz veins, occur throughout the Serpentine rock.

CHAPTER VIII.—*Sandstones and slates in the Indus Valley.*

Reddish and greenish slates and sandstones.

In the Indus valley itself the last described series of rocks is followed at first by reddish slates, and underlying these greenish sandstones and slates are visible farther on. These are the only rocks which are to be noticed all through the Indus valley along the northern border of Rupshu as far as Ronggo (properly spelt *rong*, narrow gorge, and *s'go* the door). At the mouth of the Puga stream the Indus flows in an anticlinal, the sandstones and slates dipping on the southern side to south-west, and on the northern slightly to north-east. The green and reddish sandstone have an immense thickness here, some of the hills on the northern side are seen rising 3,000 and 4,000 feet, and consisting apparently of these rocks only. It is impossible to imagine, even approximately, of what age these rocks may be, although they probably belong to a palæozoic series. No fossils whatever have been observed in them; neither during our survey, nor have I heard that anybody else has noticed any traces of organic remains in them. I have seen a few fragments of a white crystalline limestone, which has been brought from the Pangkong lakes by Capt. Godwin Austen, who informed me that the reddish and greenish rocks are there overlaid by limestone.

Age doubtful.

CHAPTER IX.—*River and Lacustrine deposits.*

River deposits.

During the previous remarks I have omitted to mention anything regarding the more recent deposits; there is however, very little to be said. In the Indus valley itself deposits, hardened sometimes to a compact conglomerate,

are to be observed several hundred feet above the present level of the river, and large alluvial plains exist in places on both sides, which must have been laid dry only at a recent period. There can be no question that the lake system in Rupshu was in former times, as noticed by Genl. A. Cunningham, a more extensive one, and that the waters have decreased constantly in their extent over the surface. Indeed they are constantly disappearing, and not only very considerably, but even very rapidly. There are but few glaciers in middle and northern Rupshu, and these nourish only a few streams, which do not become dry during the whole year. Most of them do so, but the few, which flow throughout the whole year, carry a great quantity of debris and sand into the stagnant water reservoirs ; the lakes reduce their depth, cause the water to evaporate more quickly, and at the same time to become more brackish, unfit for animal life, and at last they disappear altogether and give rise to a large plain, covered with *Carices* and inhabited by Kyangs. Where this proceeding will terminate is quite clear, and the time cannot be very far distant when all the lakes will cease to exist. At present large plains of accumulated sand are attached to every lake, and show distinctly its previous larger extent. Some of the lakes have disappeared in the very recent period, and even in the last years. As one instance I need only recall the fact that in 1847, when Genl. A. Cunningham visited Rupshu, a portion of the Hanle lake was still in existence, and Genl. A. Cunningham says, that it was once the largest sheet of water in Ladak. When we spent a few days of the middle of August round Hanle last year not a trace of the Hanle-tso was visible, and the plain, although marshy, was richly covered with *Gramineæ* and *Carices*. With regard to a second question relating to the borax and sulphur of Puga, which I may probably be supposed to notice, it is scarcely necessary to add to what has been already and repeatedly communicated in the "Selections, etc., of the Punjab Administration, Lahore,

1855," Vol. II, No. XII. The borax occurs, as known, all through the middle portion of the Puga valley, and owes, no doubt, its existence to the numerous hot springs, some of which have a temperature very near the boiling point of water of the same locality (178° F.) Except these hot springs, the country has nothing in common with a volcanic district, which name Cunningham gives to it.

The sulphur is obtained from a few holes on the northern edge of the valley; it occurs with many other minerals, as *Alum*, *common Opal* and *Satin gypsum*. The sulphur is disseminated, chiefly in small crystals, through the decomposed quartz schist. The whole must have been formed and crystallized out evidently at a much higher temperature than at present exists.

The official of the Kashmir Maharajah informed us, that the greatest amount of Borax which is carried away yearly, never exceeds 4,000 maunds, and that of Sulphur 500 maunds. This would be hardly as much as it was several years ago. The Government could not wisely do anything more than it has done, namely improve the road and leave that little trade in the hands of the boiparis, who are mostly inhabitants of Kulu.

PART III.—GENERAL REMARKS ON THE RELATIVE AGES OF THE DIFFERENT FORMATIONS.

After our detailed examination of each of the formations in the preceding pages, two important questions present themselves, to give a definite answer to which would be very desirable : *1st.*—What is the geographical extent, and what is the geological connection of the different stratified groups on the Northern side of the Himalaya? And, *2nd.*—Do these give any evidence bearing on the age of the stratified series which occur on the Southern side of the same mountain ranges?

We regret to say that as yet neither of these questions can be answered with full satisfaction; we shall briefly summarize in the following pages, what may be stated with a certain amount of confidence, on these points.

As regards that part of the first question which refers to the geographical extent of the several series, we have already had occasion to state, that only a small portion of the area to the North of the main geological axis has been as yet examined, the survey of the adjoining districts being still in progress. The districts lying to the North-west of the area examined during last year will be visited during the present season (1865). All the portions of Bissahir and Ngari, which are adjacent on the South-east, will be examined subsequently. When this has been done, we shall be able to present a geological map of the country between the Pir-Panjal range and the Indus on the one hand, and between Skardo and South-western Ngari-Khorsum, on the other. It is equally certain that, only after such an examination, should we feel justified in discussing the geological development of the North-

western Himalaya, a point requiring very careful investigation owing to its intimate relationship to that of some European ranges of mountains. A knowledge of the geological structure of the Himalaya may, very probably, again raise questions on some theoretical views of mountains, and mountain-range theories, which have long attracted so much attention from many most able observers, and for the discussion of which materials have been carefully collected, in Europe and in America, for many years past.

The second part of our first question relates to the Geological, or the stratigraphical connection of the several groups. To answer this, it may be well to give here a short review of what has been already stated in greater detail.

Looking at the continued sections of that portion of the North-western Himalayas, to which we have specially referred, it would seem to be formed of five different zones of rocks, parallel to each other, and with their main strike from North-west to South-east. As already pointed out by Genl. Cunningham, not one of these geological zones is *essentially* connected with the Geographical or orographical ranges. Whether it may be possible, after further investigation, to trace out any connection of this kind is still an interesting question.

I.—The first zone, geologically speaking, extends, I believe, from near the plains of India to the Central Gneiss; and has a breadth of about 84 miles, in a direction from South-west to North-east. Scarcely more than one-third of the entire breadth is composed of un-metamorphic, or at least of not highly metamorphic stratified rocks, comprising those groups of which Mr. Medlicott treats, with much detail, in his paper already more than once referred to. The Sivalik, Nahun and Subathoo groups belong to the Tertiary period; the age of the Krol, Infra-Krol, Blini, and Infra-Blini groups is not yet defined. These groups contain locally some truly metamorphic strata, but the greater part of these latter extends further to the

North, and consists of micaceous, chloritic, and gneissose schists and thin-bedded gneiss. Quartzose rocks are very common through all the series.

II.—The second zone is to be regarded as the principal Geological axis of the North-west Himalaya. It consists chiefly of a porphyritic gneiss (with Biotite) coarsely stratified, and traversed by veins of porphyritic Albite-granite. The breadth of this zone is about 14 miles. South of the Pin valley this central gneiss forms only the Southern branches of the Pir-Panjal range. To the South-east it seems to unite with this main range, while in its North-western extension it (the gneiss) crosses the same range, joining with the Bara-latse range, North of Lahoul.

III.—The third zone comprises the rocks lying to the North of the Central Gneiss, its breadth being about 55 miles. The rocks of this zone are only very slightly, or locally, altered by metamorphosing agencies. They represent European formations belonging to the Palæozoic, Mesozoic, and Tertiary periods. The greatest elevations in the North-western Himalaya lie within this zone, the rocks of which form a kind of basin extending from the North-west to the South-east along the northern ranges of the Himalaya. Whether these basins have been originally connected, and separated after the lapse of geological periods, or whether the different formations have been deposited in already isolated areas, is a question the solution of which can only be looked for from subsequent researches.

The centre of that portion of the basin which we have described lies in Spiti, and is indicated on the little map (Pl. I) by the extent of the Spiti shales, which are of oolitic age. To the North and South of the jurassic ellipse we have, therefore, a repetition, more or less, of the same formations; of which we have recorded the following,

1. *Bhabeh series*, probably *Lower Silurian*, consisting of sandstones, slates, and quartzites, with species of *Orthis* and *Chœtetes yak*, Salter.

2. *Muth series*, probably of Silurian age also, and consisting of three different groups of rocks, the lowest of which are purple quartzites, the middle arenaceous limestones, and the upper white quartzites. In the middle series *Orthis*, *Strophomenæ* and *Tentaculites* have been observed.

Both these series are not to be traced in Rupshu, unless they have their equivalents in the fourth zone, the metamorphic rocks.

3. *Kuling series*, consisting of white quartzites, shales, limestones and sandstones, characterized as carboniferous rocks by the abundance of *Productus semireticulatus*, *Spirifer Keilhavii* and *Moosakhailensis*, etc. The strata of this series can be traced through all Spiti and Southern Rupshu, towards the middle of the basin, in dome-form upheavements. The thickness is not considerable.

4. *Lilang series*, representing the *Upper Trias* (the Hallstadt and St. Cassian beds) by dark colored limestones and calcareous slates and shales. This series rests immediately above the carboniferous beds, and we have, therefore, the whole Permian (Dyas) and lower Trias (Muschelkalk and Bunter Sandstein) wanting in this part of the Himalayas. Their existence is not yet proved even in any other districts of these mountains.

As characteristic fossils may be quoted *Ammonites subumbilicatus*, *Ausseanus*, *fissicostatus*, *floridus* and *Studeri*, *Hallobia Lomeli*, *Athyris Strohmeyeri*, and *Deslongchampsi*. Considerable disturbances took place after the Trias.

5. *Para limestone*, black dolomitic, strongly bituminous and often earthy limestones, containing *Megalodon triqueter* and *Dicerocardium Himalayense* (n. sp.) I have restricted these beds, being quite different, mineralogically, stratigraphically, and palæontologically, from the previous, under the name Rhætic-formation, and would exclude the *Avicula contorta* beds. It need hardly be remarked, that the beds with *Megalodon triqueter* form in the Alps a most prominent

feature, and that they ought to be separated under a special name, as proposed by Gümbel and supported by Suess. A denomination, abstracted from the mineralogical character of the rock, may be locally of great service, but it cannot be universally accepted. And what advantage is gained by the compound names of *Upper Trias, Muschel-keuper, Oberkeuper, etc.,* if we have not got the proper equivalents of the strata with *Megalodon triqueter* in any of these formations ?

The Para limestone is chiefly developed on the northern side of the basin, and seems to be wanting on the southern side. It thins out already in the northern parts of Spiti. This seems to correspond very well with the great dislocations which, after the depositions of the Trias, seem to have taken place over extensive areas.

6. *Lower Tagling limestone,* a dark brown or black, often oolitic and bituminous, limestone. It rests on the southern side above the *Trias*, on the northern above the *Rhætic*, and extends over the greater part of Spiti and Southern Rupshu, in more or less horizontal strata towards the tops of hills and ranges. Its entire thickness is above one thousand feet.

The characteristic fossils are *Ammonites Germani,* D'Orb. (?) *Belemnites bisulcatus, tibeticus,* and *Budhaicus* (n. sp.) *Avicula inæquivalvis, Pecten Valoniensis, Terebratula gregaria, pyriformis* and *punctata, Waldheimia Schafhæutli, Rhynchonella variabilis, Austriaca, fissicostata,* etc. Most of these fossils are known to characterize the *Kossen* strata, which are often quoted as belonging to the Rhætic formation.

The '*Kossner-schichten*', or the beds with *Avicula contorta*, attracted special attention long since in the Alps, and have been traced since through all Europe. The later researches and even those of the last year, some of which I am sorry to say I have not yet had an opportunity of studying in detail, show that the questions relating to the

so-called 'Kossner-schichten' are far from being settled. The stratigraphical position is in most cases determined, but the difference of opinion is as to the series to which they ought to be assigned, or whether they ought not to be kept as a distinct formation altogether under a separate name. The general result, up to the present time, is that the Italian and French Geologists are chiefly in favor of referring the beds in question to the Lias, and the North Alpine Geologists are more of opinion that they have a stronger relation to the Trias. The separation under a special denomination is generally regarded as unnecessary.

I cannot entirely agree with the views of those Geologists who have devoted years to the study of the North Alpine formations And it may be of interest to state the results, which I deduce from my Himalayan Survey. The beds with *Megalodon triqueter* rest on the Upper Trias ("Hallstadter Schichten"), and seem to form a distint series to which the name *Rhætic* may probably be well restricted.

The beds with the Brachiopoda of the 'Kossner-schichten', contain, (besides the characteristic species of *Terebratula* and *Rhynchonella*) *Belemnites* and *Ammonites* of lower liassic character, and some other species identical with lower liassic fossils, as already mentioned. There is certainly no accidental mixture of those fossils which I have quoted from these lower beds. I am, therefore, inclined to the opinion of the French and Italian Geologists, that the *Avicula contorta* beds represent the lower lias. Stoppani says, that those strata of the so-called Dachstein-Kalk which rest above the Kossner-schichten do not contain *Megalodon triqueter* (M. Gümbelii !) but a liassic *Conchodon.* Although I have myself seen these strata at several places, I would not entirely trust to my own observations. The question will doubtless be settled with all needful care by our Alpine friends. In any case there seems to exist a good deal of local difference among these strata

7. *Upper Tagling limestone.* This is a dark earthy and bituminous limestone, which may be taken to represent the "Hierlatz-schichten" of the Alpine formations. I have met it only along the top of the Baralatse-range to the North of Spiti, forming the boundary towards Rupshu. To the South of the basin these beds are certainly wanting, at least locally. It is very difficult to trace mineralogically theboundary between the lower and upper Tagling limestone, although the beds with the characteristic fossils of the upper series are perfectly different. I have to mention particularly *Chemnitzia undulata, Trochus epulus, latilabrus, Terebratula Sinemuriensis.*

When I wrote the monograph on the *Gastropodu* and *Acephala* of the Hierlatz strata in 1861, I expressed the opinion, that these strata corresponded with those of the *middle Lias* of Normandy. Prof. Oppel subsequently urged the view that the 'Hierlatz-schichten' represented the lower and not the middle Lias (Bronn's Jahrb. 1862), and even threw doubt on some of my identifications of the fossils. I did not reply at that time to Prof. Oppel's opinion, because I thought it merely a trifling matter, and it was evident from my paper, that I declared the "Hierlatz-schichten" to be middle Lias only on the ground of identity of some fossils with others from Normandy, where the representative strata are believed to be of middle liassic age. Of those supposed identical fossils, which I quoted in my paper, I fully think still, as I did then, and would not recall even a single one; on the contrary I would rather increase their number. Having treated the previous group as *lower Lias,* I must of course still persist in my previously expressed opinion, that the *Hierlatz-schichten* of the Alps, or the *Upper Tagling limestone* of the Himalayas represent the *Middle Lias.*

8. *Jurassic earthy slates,* with Belemnites and a species of Posidonomya very like *Pos. Am. ornati* have been noticed South of Gieumal above the lower Tagling limestone. They seem to be only very

locally developed, and may prove to be only a local alteration of the next series.

9. *Spiti shales.* A black crumbling rock full of calcareous concretions. Its extent is limited, with the following secondary formations to Spiti only, and is indicated on our sketch map (Plate I). The characteristic fossils are *Am. macrocephalus, Parkinsoni, curvicosta, liparus, triplicatus,* and *biplex, Astarte major* and *unilateralis, Nucula cuneiformis, Trigonia costata,* etc.

Without entering at present on the questions of separate zones, I believe the best equivalent of these beds is Quenstedt's *Brown Jura,* or now usually called *Dogger,* comprising a great number of so-called formations, clays, limestones, sandstones, shales, etc., which have in England, France, Germany, etc., only local value. The Himalayan Jura approaches in many respects in the character of its fossils to the Russian. It is a mistaken opinion to regard certain beds, which contain *Planulati-Ammonites* as *upper Jura.* The Spiti shales have been treated in this manner, because they abound in "Planulati." But all those we do find *Am. curvicosta, Braikenridgii, triplicatus* and the Kimmeridgien form of *Am. biplex, all* these species are not upper but middle jurassic; even if we could abstract all the rest of the fossils. *Trigonia costata* proves nothing, as it goes through many strata without essential alteration, similarly the *Avicula inæquivalvis.* The Cutch deposits are equally not of *upper* but of *middle jurassic* age, and have a great number of species identical with the *oolite inferieur* of *Bayeux* and *Montreuil Belly.*

10. *Gieumal sandstone;* yellowish or white quartzitic and calcareous sandstones characterized by the occurrence of *Opis, Anatina, Avicula echinata* and *Amusium demissum.* From their stratigraphical position I believe these strata to represent the upper Jura or *Malm;* the fossils found do not afford quite satisfactory evidence.

11. *Chikkim limestone,* by its white or bluish colour very much recalling the *Rudisten limestones* of the Alps, and being an equivalent

of one or the other of those beds. From the character of the Foraminifera and the fragments of Rudistes they probably correspond best with the middle series of these limestones. There seems to be no Neocomian developed.

12. *Chikkim shales* form the uppermost, probably secondary, strata and seem to be closely connected with the previous limestones. No fossils have been traced in them.

13. *Karéwah deposits.* The extensive river and lacustrine accumulations of debris, conglomerate and deposits of clays and sand, have been so called. They are of very great thickness, to be observed nearly along all the principal rivers, and are no doubt, equally as those in the Alps, of different ages. But scarcely any of them will, I believe, be proved to be of real marine origin, as these parts of the country must have been at this time already very highly elevated above the level of the sea.

IV. The fourth zone occupies middle and northern Rupshu. It extends from the termination of the Tsomoriri in the Para valley to a little beyond Puga, a distance of about 35 miles. The chief rock is a quartzose and micaceous schist, with a few interruptions from granitoid gneiss. There is black Tourmalin present, but no veins of Albite granite are to be observed, and the gneiss does not seem to have caused any particular dislocations or disturbances in the metamorphic series. To the North of this zone I have previously remarked the *Epidote, Diallage* and *Serpentine rocks,* the latter of which contain often *Chromic iron.* The last strata which have been noticed, and which represent the next or *fifth zone,* are *slates and sandstones* of doubtful age, but probably very old.

We come now to our second question, whether the examination of the rocks on the northern side of the Himalayas has afforded any materials, from which the age of the strata on the southern declivities can be traced. I shall restrict my remarks to the Simla section only.

Referring to Mr. Medlicott's section (Mem. III. part. 2, p. 32) from below Simla to Hatu near Narkanda, we leave, proceeding to South, the metamorphic strata a few miles South* of Muttiani. The metamorphic strata I would identify with the lower and middle beds of the *Bhabeh series.* The Infra-Blini sandstones and Simla slates, which extend from South of Muttiani to Simla, I think represent the greenish sandstones and slates of the upper beds of the *Bhabeh series.*

The *Blini conglomerate* and purple sandstone is mineralogically nearly identical with the lowest beds of the Muth series; the *Blini limestone* seems to be represented to the North by the arenaceous limestone of the middle beds; and the upper quartzite of the *Muth series* by a small thickness of a whitish, quartzose schist, which is to be seen above the *Blini limestone* all round Simla. The *quartzose beds* on the Boileaugunj hill and the *Garnetiferous mica-schist* on Jako may have their representatives in the *Kuling or Carboniferous series.*

For the *Infra-Krol* beds, on the Krol mountain itself, I have nothing to compare with on the North of the Himalayas, but I would not like to identify them with the beds on Jako at Simla. When I first saw the Infra-Krol beds near Masuri in 1863, I believed them to be mineralogically so very identical with the "Bunter Sandstein" of the lower Trias, that I felt very much distressed not to find a *Posidonomya Claræ* or *Myacites fassaensis.* I have not been able to find any support for this opinion, neither was my impression during the visit of last year different from that previously produced.

The *Krol limestone,* especially those characteristically oolitic beds of black limestone, I would incline very much to identify with the similar limestones at Muth, belonging to our *Lilang series,* and representing the Alpine *upper Trias.* But there is here equally no palæontological

* At the point where, on Mr. Medlicott's section, an indication is given of closer striation.

support whatever, and until fossils have been found at least in one or the other of the southern Himalayan rocks nothing else can give full satisfaction. The Tertiary rocks are not represented, in that portion of the Northern Himalayas which has been examined last year, but they are known to exist farther to North-West. Should the foregoing identification prove only approximately to be correct, it is strange to think we have all the liassic, jurassic and cretaceous strata wanting on this side of the Himalayas, and still they are known to exist, at least partially, in the Punjab and further to the South in Cutch. Large is still the field for geologists in India!

TABULAR LISTS

of the Fossils described in the preceding pages, shewing their distribution in the several formations, together with references to page and plate of the descriptions.

Genera and Species.	Description and Figure in this Paper. Plate. Figure.	Page.	Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
PLANTÆ.												
Sphæro-coccites, (?) ...	....	22	*	..	..	..	..	..	..	..	..	..
FORAMINIFERA.												
Cristellaria, *sp.*	....	118	..	..	..	..	..	..	..	..	..	*
Dentalina, *sp.*	....	118	..	..	..	..	..	..	..	..	..	*
Globulina, *sp.* (?)	....	30	..	..	*	..	..	..	..	..	..	..
Haplophragmium, *conf.* irregulare, *Reuss.*	....	118	..	..	..	..	..	..	..	..	..	*
Quinqueloculina, (?) ...	....	30	..	..	*	..	..	..	..	..	..	..
Rotalia, *sp.*	....	118	..	..	..	..	..	..	..	..	..	*
Textilaria, *sp. sp.*	....	118	..	..	..	..	..	..	..	..	..	*
POLYPARIA.												
Chætetes Yak, *Salter,* ...	....	21	*	..	..	..	..	..	..	..	..	..
Cyathophyllum, *sp. sp.* ...	....	22	*	..	..	..	..	..	..	..	..	..
Lithodendron, (?)	....	..	..	..	*	*	..	..	..	..	..	..
Syringopora, *sp.*	....	22	*	..	..	..	..	..	..	..	..	..
ECHINODERMATA.												
Crinoid stems	....	19 37	*	*	*	..	..	..	..	..	..	..
Encrinus Cassianus, (?) *Laube,*	....	37	..	..	*	..	..	..	..	..	..	..
Salenia (?)	....	86	..	..	..	..	..	..	..	*	..	..

Genera and Species.	Description and Figure in this Paper. Plate. Figure.	Description and Figure in this Paper. Page.	Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone 'Malm.'	Chikkim limestone, Cretaceous.
BRACHIOPODA.												
Athyris Deslongchampsi, *Suess*, ...	....	43	..	..	*	..	..	..	..	..	..	..
Athyris Strohmeyeri, *Suess*,	....	43	..	..	*	..	..	..	..	..	.	..
Orthis, *conf.* compta, *Salter*,	....	23	*	..	..	..	..	..	..	..	..	..
„ *conf.* resupinata, *Phill.*	....	23	*	..	..	..	..	..	..	..	..	..
„ *conf.* thakil, *Salter*,												
„ *var* α convexa, *Salter*,	....	23	*	..	..	..	..	..	..	..	..	..
„ „ δ striato-costata, *Salter*, ...	....	23	*	..	..	..	..	..	..	..	..	..
„ *conf.* tibetica, *Salter*,	.. .	23	*	..	..	..	..	..	..	..	..	..
Productus longispinus, *Sow.*	....	29	..	*	..	..	..	..	..	..	..	..
„ Purdoni, *Dav.*,	....	29	..	*	..	..	..	..	..	..	..	..
„ semi-reticulatus, *Martin*, ...	....	29	..	*	..	..	..	..	..	..	..	..
Rhynchonella Austriaca, *Suess*, ...	....	71	..	..	..	..	*	..	..	..	..	..
„ fissicostata, *Suess*, ...	....	70	..	..	..	..	*	..	..	..	..	..
„ mutabilis, *Stol.* ...	III. 6-9	40	..	..	*	..	..	..	..	..	.	..
„ obtusifrons, *Suess*, ...	....	70	..	..	..	..	*	..	..	..	..	..
„ pedata, *Bronn.*	....	70	..	..	..	..	*	..	..	..	..	..
„ retrocita, *Suess*, „ *var*, angusta, *Stol.* ...	III. 13	42	..	..	*	..	..	..	..	..	..	..
„ ringens, *Herault*, ...	....	71	..	..	..	..	*	..	..	..	..	..

Genera and Species.	Description and Figure in this Paper.		Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
	Plate. Figure.	Page.										
Brachiopoda.—(*Cd.*)												
Rhynchonella Salteriana, *Stol.*	III. 11-12	41	..	..	*	..	..	..	..	..	..	..
" Theobaldiana, *Stol.*	III. 10	41	..	.	*	..	..	..	..	..	..	..
" variabilis, *Schloth.* ...	....	71	..	..	..	..	*	..	..	..	..	..
" varians, *Sow*	....	87	..	..	..	..	..	..	..	*	..	..
Spirifer altivagus, *Stol.* ...	III. 3	28	.	*	..	..	..	..	..	..	..	..
" *conf.* fragilis, *Schloth.*	....	38	..	..	*	..	..	..	..	..	..	..
" Keilhavii, *Buch.* = *S. Rajah*, Salter ...	....	27	..	*	..	..	..	..	..	..	..	..
" Lilangensis, *Stol.* ...	III. 4	38	..	..	*	..	..	..	..	..	..	..
" Moosakhailensis, *Dav.*	....	27	..	*	..	..	..	..	..	..	..	..
" *Rajah, Salter*, vid. S. Keilhavii, ...												
" *sp. nov.*	....	37	..	..	*	..	..	..	..	..	..	..
" Spitiensis, *Stol.* ...	III. 5	39	..	..	*	..	..	..	..	..	..	..
" Stracheyi, *Salt.* ...	....	38	..	..	*	..	..	..	..	..	..	..
" Tibeticus, *Stol.* ...	III. 1-2	28	..	*	..	..	..	..	..	..	..	..
Strophomena *conf.* halo, *Salt.*	....	23	*	..	..	..	..	..	..	..	...	..
Terebratula gregaria, *Suess.*	....	68	..	..	..	..	*	..	..	..	..	..
" punctata, *Sow.*	....	68	..	..	..	..	*	..	..	..	..	..
" pyriformis, *Suess.* ...	....	68	..	..	..	..	*	..	..	..	..	..
" Schaffhæutli, *Stopp.* = *T. Cornuta, Sow.*	....	69	..	..	..	..	*	..	..	..	..	..
Sinemuriensis, *Opp.*	....	80	..	..	..	..	..	*	..	..	..	..

Genera and Species.	Description and Figure in this Paper. Plate. Figure.	Page.	Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
Brachiopoda.—(*Cd.*)												
Terebratula *Sp.*	....	87	..	..	..	..	..	..	..	*	..	..
Waldheimia Stoppanii, *Suess.*	....	44	..	..	*	..	..	..	..	..	..	..
RUDISTA.												
Fragments of	....	117	..	..	..	..	..	..	..	..	..	*
PELECYPODA.												
Amusium demissum, *Bean.* sp. (*Pecten* id.) ...	....	115	..	..	..	..	..	..	..	..	*	..
„ *conf.* solidum, *Trautsch.* ...	....	87	..	..	..	..	..	..	..	*	..	..
„ *sp.*	....	72	..	..	..	..	*	..	..	..	..	..
Anatina Spitiensis, *Stol.* ...	X. 4	115	..	..	..	..	..	..	..	..	*	..
„ *sp.*...	....	116	..	..	..	..	..	..	..	..	*	..
Arca, (*vide* Macrodon) ...												
„ „ **Lycetti, *Moore.***	....	76	..	..	..	..	*	..	..	..	..	..
Astarte hiemalis, *Stol.* ...	IX. 2, 3	91	..	..	..	..	..	..	..	*	..	..
„ **major, *Sow.*** ...	....	91	..	..	..	..	..	..	..	*	..	..
„ **Spitiensis, *Stol.*** ...	IX. 9	91	..	..	..	..	..	..	..	*	..	..
„ **unilateralis, *Sow.*** ...	....	90	..	..	..	..	..	..	..	*	..	..
Aucella Blanfordiana, *Stol.*	....	88	..	..	..	..	..	..	..	*	..	..
„ **leguminosa, *Stol.***...	VIII. 8	88	..	..	..	..	..	..	..	*	..	..
Avicula echinata, *Sow.* ...	....	114	..	..	..	..	..	..	..	..	*	..
„ **inequivalvis, *Sow.***	....	75	..	..	..	..	*	..	..	..	..	..
„ **punctata, *Stol.*** ...	VI. 2	76	..	..	..	..	*	..	..	..	..	..
„ ***sp.***	....	29	..	*	..	..	..	..	..	..	..	..
Aviculo-pecten, *sp.* ...	....	29	..	*	..	..	..	..	..	..	..	..

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Pelecypoda.—(*Continued.*)												
Cardiomorpha, *sp.*	....	29	..	*	..	..	..	..	..	..	..	..
Cyprina trigonalis, *Blanf.*	....	90	..	..	..	..	..	..	..	*	..	..
Dicerocardium Himalayense, *Stol.*	VII.	63	..	..	..	*	..	..	..	..	..	..
Gervillia, *sp.*	....	76	..	..	..	..	*	..	..	..	..	..
Gryphæa, *sp.*	....	114	..	..	..	..	..	..	..	..	*	..
Halobia Lommeli, *Wissm.*	....	44	..	..	*	..	..	..	..	..	..	..
Homomya Tibetica, *Stol.* ...	IX. 4	92	..	..	..	..	..	..	..	*	..	..
Inoceramus Hookeri, *Salt.*	....	89	..	..	..	..	..	..	..	*	..	..
Lima, *conf.* **Ramsaueri**, *Hörnes*, ...	....	45	..	..	*	..	..	..	..	..	..	..
" **densicosta**, *Quenst.*	....	75	..	..	..	..	*	..	..	..	..	..
" *n. sp.* (*like* scrobiculata, *Stol.*)	....	45	..	..	*	..	..	..	..	..	..	..
" *n. sp.*	....	45	..	..	*	..	..	..	..	..	..	..
" *sp.* (*like* rigida, *Desh.*)	....	89	..	..	..	..	..	..	..	*	..	..
" *sp.*	....	115	..	..	..	..	..	..	..	..	*	..
Macrodon Egertonianum, *Stol.*	VIII. 7	89	..	..	..	..	..	..	..	*	..	..
Megalodon triqueter, *Wulf.*	....	64	..	..	..	*	..	..	..	..	..	..
Modiola, *sp.*...	....	81	..	..	..	..	..	*	..	..	..	..
Myoconcha Lombardica, *Hauer*, ...	....	45	..	..	*	..	..	..	..	..	..	..
Mytilus mityloides, *Blanf.*	....	115	..	..	..	..	..	..	..	..	*	..
Neoschizodus, *sp.*	....	62	..	..	..	*	..	..	..	..	..	..
Nucula cuneiformis, *Sow.*...	....	90	..	..	..	..	..	..	..	*	..	..
" *sp.*	....	90	..	..	..	..	..	..	..	*	..	..

GENERA AND SPECIES.	DESCRIPTION AND FIGURE IN THIS PAPER. Plate. Figure.	Page.	Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low Tagling limestone, Low. Lias.	Up Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
PELECYPODA.—(*Continued.*)												
Opis, *sp.*	....	116	..	..	..	..	..	..	..	..	*	..
Ostrea *conf.* acuminata, *Sow.*	....	72	..	..	..	..	*	..	..	..	..	.
„ *conf.* anomala, *Terquem,*	....	72	..	..	..	..	*	..	..	..	..	..
„ flabelloides, (?) *Lam.*	....	87	..	..	..	..	..	..	..	*	..	..
„ gregaria, *Sow.* (?)...	....	114	..	..	..	..	..	..	..	..	*	..
Pecten (in part) *see Amusium*												
„ bifrons, *Salt.* (partim)	....	74	..	..	..	..	*	..		..	..	..
„ „ „ „ ...	....	115	..	..	..	..	..	..	..	..	*	..
„ *conf.* palosus, *Stol.*...	....	73	..	..	..	..	*	..	..	..	..	..
„ lens, *Sow.*	....	87	..	..	..	..	..	..	..	*	..	..
„ monilifer, *Sow.* ...	....	73	..	..	..	..	*(?)	..	..	..	..	..
„ sabal, *Salt.*... ...	....	73	..	..	..	..	*	..	.	..	..	..
„ Valoniensis, *Defr.*...	....	75	..	..	..	..	*	..	..	..	..	..
Posidonomya Ornati, *Quenst.*	....	84	..	..	..	..	..	..	*	..	..	..
Trigonia costata, *Park.* ...	....	90	..	..	..	..	..	..	..	*	..	..
GASTROPODA.												
Actæonina *conf.* cincta, *Goldf.*	....	82	..	..	..	..	..	*	..	..	..	..
Chemnitzia *conf.* coarctata, *Desh.* ..	....	77	..	..	..	..	*	..	..	..	..	..
„ *conf.* Phidias, *D'Orb.* ...	....	77	..	..	..	..	*	..	..	..	..	..
„ undulata, *Reuss,*	....	81	..	..	..	..	..	*	..	..	..	..
Dentalium *conf.* giganteum, *Phill.*	....	76	..	..	..	..	*	..	..	..	..	..
Discohelix, *sp.*	....	46	..	..	*	..	..	..	..	..	..	..

GENERA AND SPECIES.	DESCRIPTION AND FIGURE IN THIS PAPER. Plate. Figure.	Page.	Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
GASTROPODA.—(*Continued.*)												
Encyclus, *sp.*	....	82	..	..	..	..	..	*	..	..	..	..
Natica, *conf.* pelops, *D'Orb.*	....	77	..	..	..	..	*	..	..	..	..	..
Nerinea, sp., *conf.* N. Goodhallii, *Sow.*	....	77 82	..	..	..	..	*	*	..	..	..	..
Nerita, *sp. nov.*	....	76	..	..	..	..	*	..	..	..	..	..
Neritopsis *conf.* elegantissima, *Hörnes*	....	81	..	..	..	..	..	*	..	..	..	..
Pleurotomaria *conf.* Buchi,	....	46	..	..	*	..	..	..	..	..	..	..
" *sp. sp.* ...	....	92	..	..	..	..	..	..	..	*	..	..
" sterilis, *Stol.*	IV. 1	46	..	..	*	..	..	..	..	..	..	..
Trochus attenuatus, *Stol.* ...	....	82	..	..	..	..	..	*	..	..	..	..
" epulus, *D'Orb.* ...	...	82	..	..	..	..	..	*	..	..	..	..
" latilabrus, *Stol.* ...	....	81	..	..	..	..	..	*	..	..	..	..
CEPHALOPODA.												
Ammonites acucinctus, *Strach.* ...	....	92	..	..	..	..	..	..	..	*	..	..
" *Adolphi*, Opp. = acucinctus...												
" alatus, *Strach.*	....	110	..	..	..	..	..	..	..	*	..	..
" Ausseanus, *Hauer,* ...	....	53	..	..	*	..	..	..	..	..	..	..
" Batteni, *Strach.*	V. 2 : VI. 1	59	..	..	*	..	..	..	..	..	..	..
" biplex, *Sow.* ...	....	109	..	..	..	..	..	..	..	*	..	..
" *Blanfordi*, Salter, = thuillieri, *Opp.*												
" Braikenridgii, *Sow.*	....	106	..	..	..	..	..	..	..	*	..	..
" *Cautleyi*, Opp. = Spitiensis ...												

Genera and Species.	Description and Figure in this Paper. Plate. Figure.	Page.	Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
Cephalopoda.—(*Contd.*)												
Ammonites *circumspinosus*, Opp. = *inflatus macrocephalus*, Quenst. ...												
= liparus, Opp.	....	107	..	..	..	..	..	..	..	*	..	..
" curvicosta, *Opp.*	....	105	..	..	..	..	..	..	..	*	..	..
" difissus, *Hauer*,	V. 4	53	..	..	*	..	..	..	.	..	..	..
" floridus, *Wulf.*	....	51	..	..	*	..	..	..	..	..	..	..
" *funatus*, Opp. = triplicatus, *Sow.*												
" Gaytani, *Klipst.*	....	53	..	..	*	..	..	..	..	..	..	..
" Gerardi, *Blanf.*	....	54	..	..	*	..	..	..	..	..	..	..
" *conf.* Germanii, *D'Orb.* ...	...	77	..	..	..	..	*	..	..	..	..	..
" *Griffithii*, Strach. = Theodorii, *Opp.*... ...												
" *Groteanus*, Opp. = Spitiensis, *Blanf.* ...												
" *Hookeri*, Strach. = octagonus, *Strach.* ...												
" Hyphasis, *Blanf.*	X. 2	97	..	..	..	..	..	..	..	*	..	..
" *interruptus*, Ziet. = Germanii, *Opp.*												
" Jollyanus, *Opp.*	....	51	..	..	*	..	..	..	..	..	..	..
" *Jubar*, Strach. = Sabineanus, *Opp.* ...												
" Khanikofi, *Opp.*	....	52	..	..	*	..	..	..	..	..	..	..

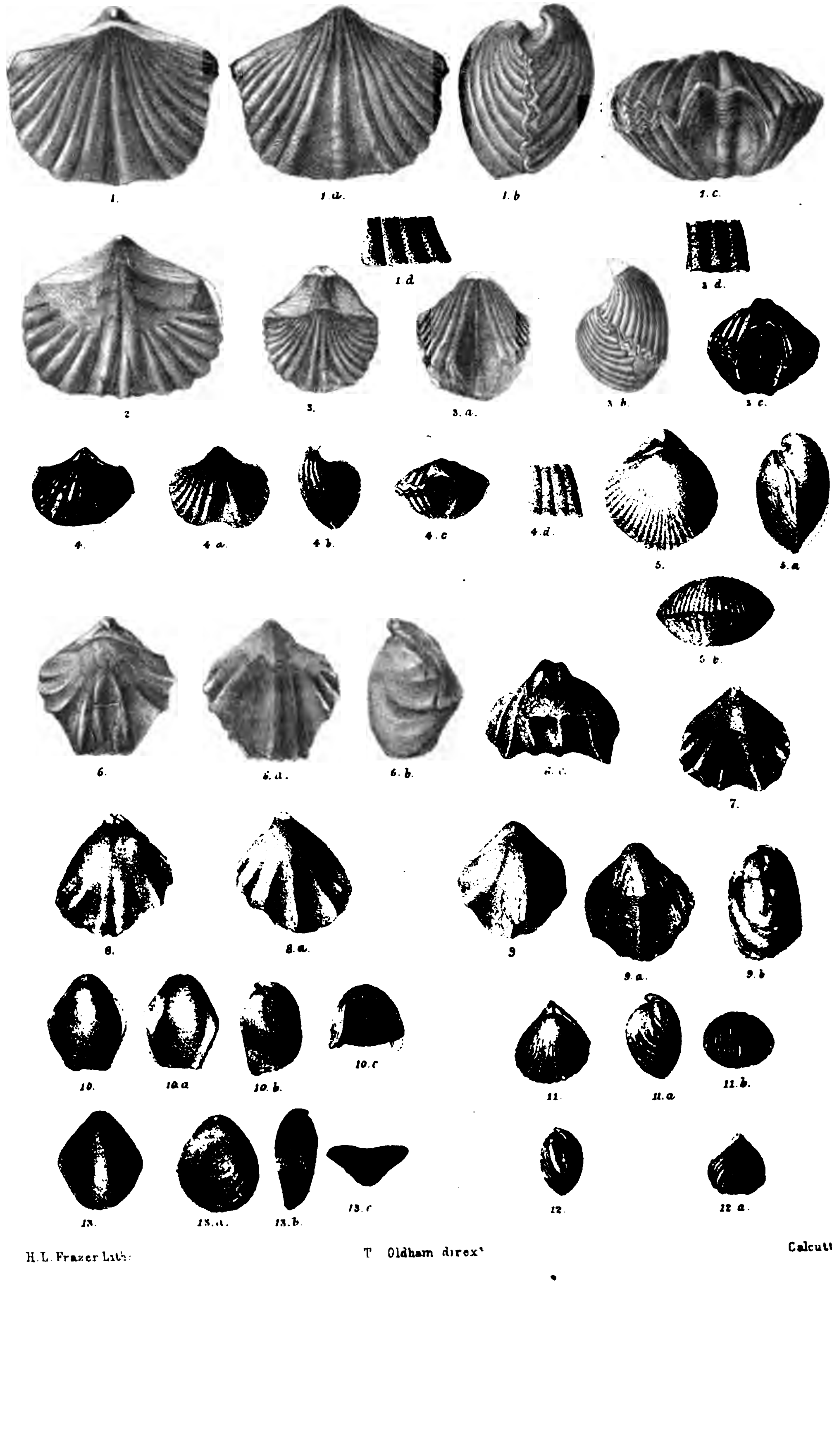
Genera and Species.	Description and Figure in this Paper. Plate. Figure.	Page.	Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
Cephalopoda.—(*Contd.*)												
Ammonites *Kimmeridiensis*, Seebach, = biplex, *Sow.*												
,, liparus, Opp....	....	107	..		..	..	..	.		*	..	..
,, *Leymanni*, Opp. = acucinctus, *Strach.*												
,, Malletianus, *Stol.*	V. 1	58	..	..	*	..	..	..	..	..	..	..
,, Medleyanus, *Stol.*	IV. 5	54	..	..	*	..	..	..	..	..	..	..
,, macrocephalus, *Schlot.* ...	....	95	..	..	..	..	..	..	..	*	..	..
,, *conf.* macrocephalus, *Schlot.*	....	83 78		..	..	..	*	*		..	..	..
,, *Moerikeanus*, Opp. = Parkinsoni, *Sow.*												
,, *Nepalensis*, Gray = macrocephalus, *Schlot.*												
,, nivalis, *Stol.* ...	X. 1	106	..	..	..	..	..	..	.	*	..	..
,, octagonus, *Strach.* ...	...	96	..	..	..	..	..	..	..	*	..	..
,, Parkinsoni, *Sow.*	....	98	..	..	..	..	..	..		*	..	..
,, *Pichleri*, Opp. = acucinctus, *Strach.* ...												
,, Sabineanus, *Opp.*	...	101	..	..	..		..	..	..	*	..	..
,, *scriptus*, Blanf. = Spitiensis, *Blanf.*												

Genera and Species.	Description and Figure in this Paper. Plate. Figure.	Page.	Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
Cephalopoda.—(*Contd.*)												
Ammonites *Seideli*, Opp. = Hyphasis, *Blanf.*												
„ *Sæmeringii*, Opp. = octagonus, *Strach.*												
„ Spitiensis, *Blanf.*	...	102	..	..	..	..	..	..	..	*	..	..
„ *Stanleyi*, Opp. = *scriptus*, Blanf. = Spitiensis, *Blanf.*												
„ strigilis, *Blanf.*	....	95	..	..	..	..	..	..	..	*	..	..
„ Studeri, *Hauer*,	....	55	..	..	*	..	..	..	..	..	..	..
„ *substriatus*, Opp. = ? acucinctus, *Strach.*												
„ *tenuistriatus*, Gray = Sabineanus, *Opp.*												
„ Theodorii, *Opp.*	IX. 5	99	..	..	..	..	..	..	.	*	..	..
„ Thuillieri, *Opp.*	....	56	..	..	*	..	..	..	..		..	..
„ *torquatus*, Blanf. = Braikenridgii, *Sow.*												
„ triplicatus, *Sow.*	....	108	..	..	..	..	..	..	..	..	..	..
„ *umbo*, Strach. = *Voiti*, Oppel, = Hyphasis, *Blanf.*												
„ *Wallichii*, Gray, = Parkinsoni, *Sow.*												
Anisoceras Gerardianum, *Stol.*	X. 3	110	..	..	..	..	..	..	..	*	..	..

Genera and Species.	Description and Figures in this Paper. Plate. Figure.	Page.	Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Mid. Lias.	Up. Tagling limestone, Low. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
Cephalopoda.—(*Contd.*)												
Belemnites bisulcatus, *Stol.*	VIII. 1-4	78	..	..	..	..	*	..	..	..	..	..
„ **Budhaicus**, *Stol.*	VI. 3-6	78	..	..	..	..	*	..	..	..	..	..
„ **canaliculatus**, *Schlot.*	....	111	..	..	..	..	..	..	..	*	..	..
„ **clavatus**, *Blainv.*	....	112	..	..	..	..	..	..	..	*(?)	..	..
„ *sp.* (?)	....	83	..	..	..	..	..	*	..	..	..	..
„ *sp.* (?)	....	84	..	..	..	..	..	..	*	..	..	..
„ **Tibeticus**, *Stol.*	VIII. 5-6	79	..	..	..	..	*	..	..	..	..	..
Clydonites Hauerinus, *Stol.*	IV. 3	50	..	..	*	..	..	..	..	..	..	..
„ **Oldhamianus**, *Stol.*	IV. 4	50	..	..	*	..	..	..	..	..	..	..
Nautilus Spitiensis, *Stol.* ...	IV. 2	49	..	..	*	..	..	..	..	..	..	..
Orthoceras dubium, *Hauer*,	....	48	..	..	*	..	..	..	..	..	..	..
„ **latiseptum**, *Hauer*, ...	....	48	..	..	*	..	..	..	..	..	..	..
„ **salinarium**, *Bronn*.... ...	....	48	..	..	*	..	..	..	..	..	..	..
„ *sp.*	....	48	..	..	*	..	..	..	..	..	..	..
„ *sp.*	....	29	..	*	..	..	..	..	..	..	..	..
Annelida.												
Tentaculites, *sp.*	....	23	*	..	.	..	..	..	..	..	..	..
Vertebrata.												
Fish remains	....	61	..	..	*	..	..	.	..	..	..	..

GENERAL SUMMARY.

	Silurian.	Carboniferous.	Triassic.	Rhætic.	Liassic, Lower.	Liassic, Middle.	Jurassic.	Jurassic, 'Dogger.'	Jurassic, 'Malm.'	Cretaceous.
Plantæ	1	..	..	..	..	..	..	..	..	..
Foraminifera ...	..	..	2	..	..	..	..	..	..	..
Polyparia... ...	3	..	1	1	..	..	..	..	..	..
Echinodermata ...	1	1	1	1	..	..	..	1	..	..
Brachiopoda ...	6	7	11	..	10	1	..	2	..	..
Rudista	..	..	..	..	..	..	..	..	..	[illegible]
Pelecypoda ...	..	3	4	3	14	2	1	17	8	..
Gastropoda ...	..	..	3	..	6	7	..	1	..	..
Cephalopoda ...	..	..	18	..	5	1	1	18	..	..
Annelida	1	..	..	..	..	..	..	..	..	..
Total ...	12	11	40	5	35	11	2	39	8	1



H. L. Frazer Lith: T. Oldham direx[t] Calcutta

PLATE III.

Kuling Series.

FIGS. 1, 2. SPIRIFER TIBETICUS, *Stoliczka*, p. 28. Fig. 1, Specimen with smaller and more incurved beak, and a narrower area; Fig. 2 Specimen with less incurved beak, and a larger area; from the Carboniferous rocks of Spiti.

FIG. 3. SPIRIFER ALTIVAGUS, *Stoliczka*, p. 28. The only specimen yet known, found with the former.

Lilang Series.

FIG. 4. SPIRIFER LILANGENSIS, *Stoliczka*, p. 38, from Lilang on the Lingti River; *Lilang series.*

FIG. 5. SPIRIFER SPITIENSIS, *Stoliczka*, p. 39, from Lilang on the Lingti River.

FIGS. 6-9. RHYNCHONELLA MUTABILIS, *Stoliczka*, p. 40. Fig 6 is the most regular and common form; Fig. 7, specimen with only two unequal plaits in the sinus; 8, rather depressed specimen with only one plait; 9, inflated specimen with slightly prolonged fold, and with only two lateral plaits. All from Lilang, on the Lingti.

FIG 10. RHYNCHONELLA THEOBALDIANA, *Stoliczka*, p. 41, from Muth.

FIGS. 11-12. RHYNCHONELLA SALTERIANA, *Stoliczka*, p. 41, Fig. 11, Specimen from Lilang; Fig. 12, specimen from the neighbourhood of Hallstadt in the Austrian Alps.

FIG. 13. RHYNCHONELLA RETROCITA, (*Suess*) var. ANGUSTA, *Stoliczka*, p. 42, from Lilang. *Lilang series.*

All the specimens figured are in the Geological Survey collection.

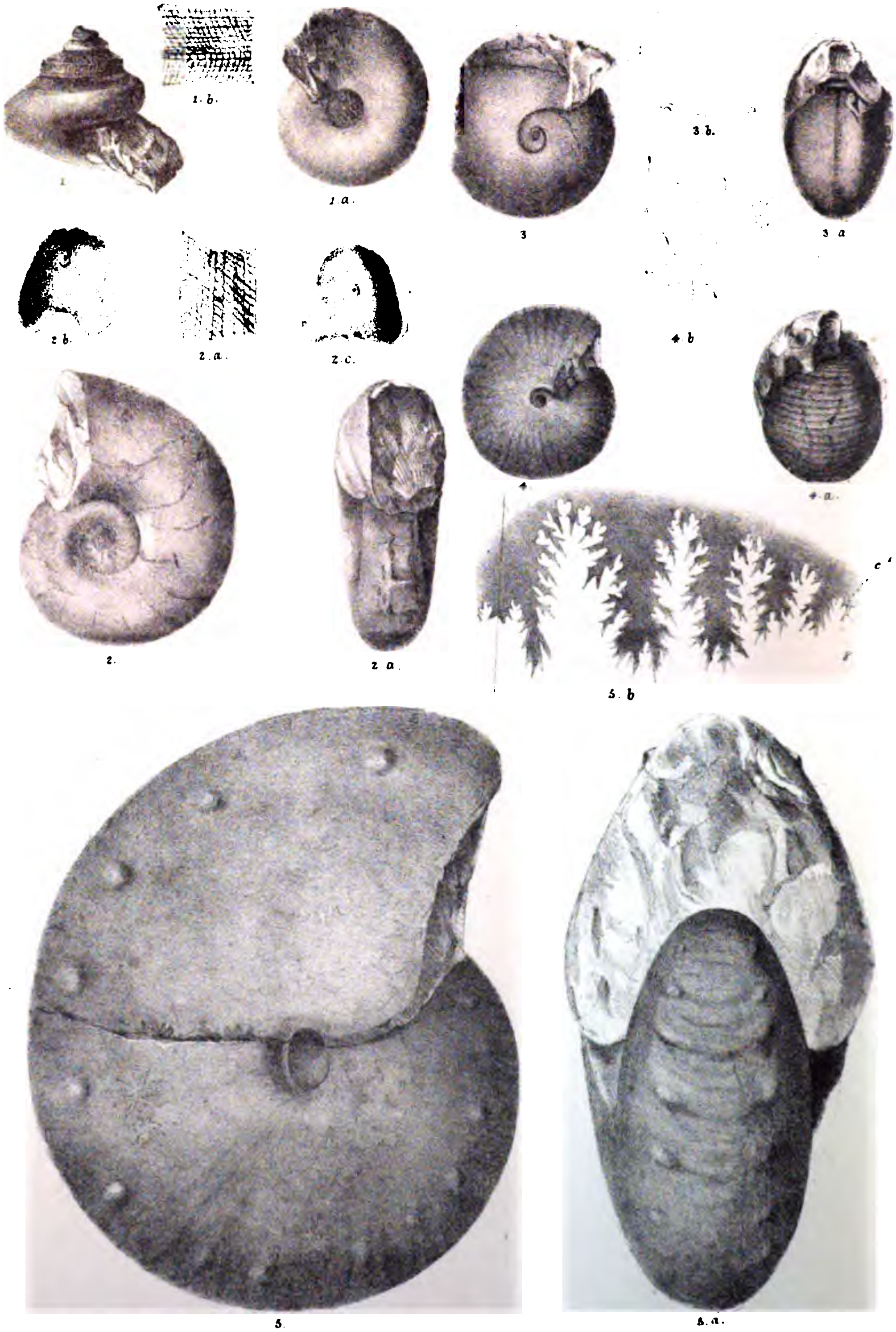


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PLATE IV.

Lilang Series.

FIG. 1. PLEUROTOMARIA STERILIS, *Stoliczka*, p. 46. The last whorl is devoid of the shell; Fig. 1*b* shows the striation on the whole breadth of one whorl; from Lilang, on the Lingti.

FIG. 2. NAUTILUS SPITIENSIS, *Stoliczka*, p. 49. Fig. 2*b* the concave, 2*c* the convex view of one septum; 2*d* shows a portion of the reticulate striation of the shell surface. From Lilang.

FIG. 3. CLYDONITES HAUERINUS, *Stoliczka*, p. 50, 3*b* shows the outline of a septum from another specimen not so perfect. From Lilang.

FIG. 4. CLYDONITES OLDHAMIANUS, *Stoliczka*, p. 50, 4*b* shows the outline of a septum of the same specimen: Lilang.

FIG. 5. AMMONITES MEDLEYANUS, *Stoliczka*, p. 54, probably from Kuling in the Pin valley.

All the specimens are in the Geological Survey collection.

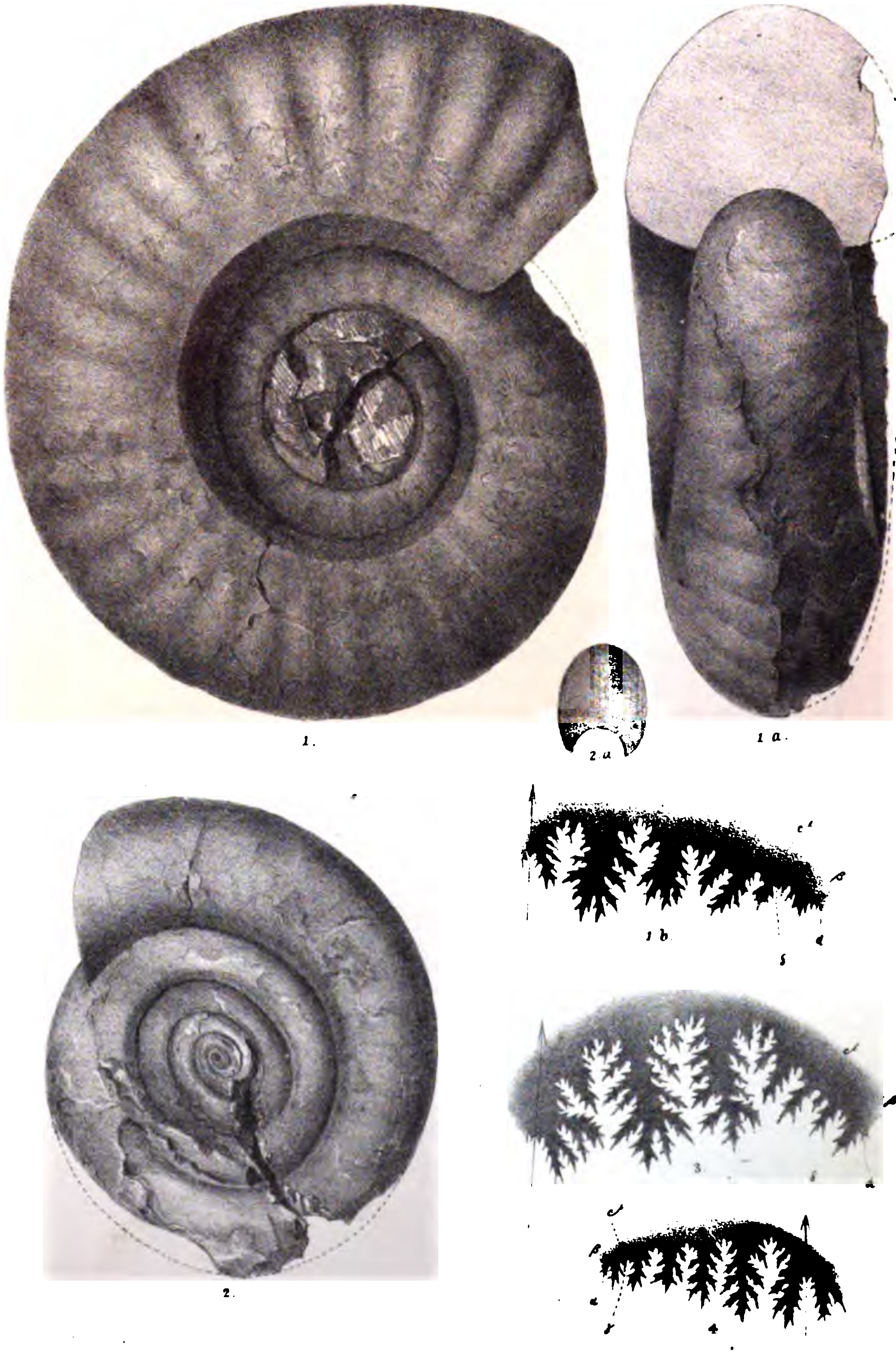

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PLATE V.

Lilang Series.

FIG. 1. AMMONITES MALLETIANUS, *Stoliczka*, p. 58, the only specimen yet known; from Lilang.

FIG. 2. AMMONITES BATTENI, *Strachey*, p. 59, variety with narrow but thick whorls; from Lilang.

FIG. 3. AMMONITES BATTENI. Outline of a septum from specimen figured on Pl. VI. fig. 1.

FIG. 4. AMMONITES DIFISSUS, *Hauer*, p. 53, outline of a septum of a large specimen.

All belong to the *Lilang Series*, and are in the Geological Survey collection.

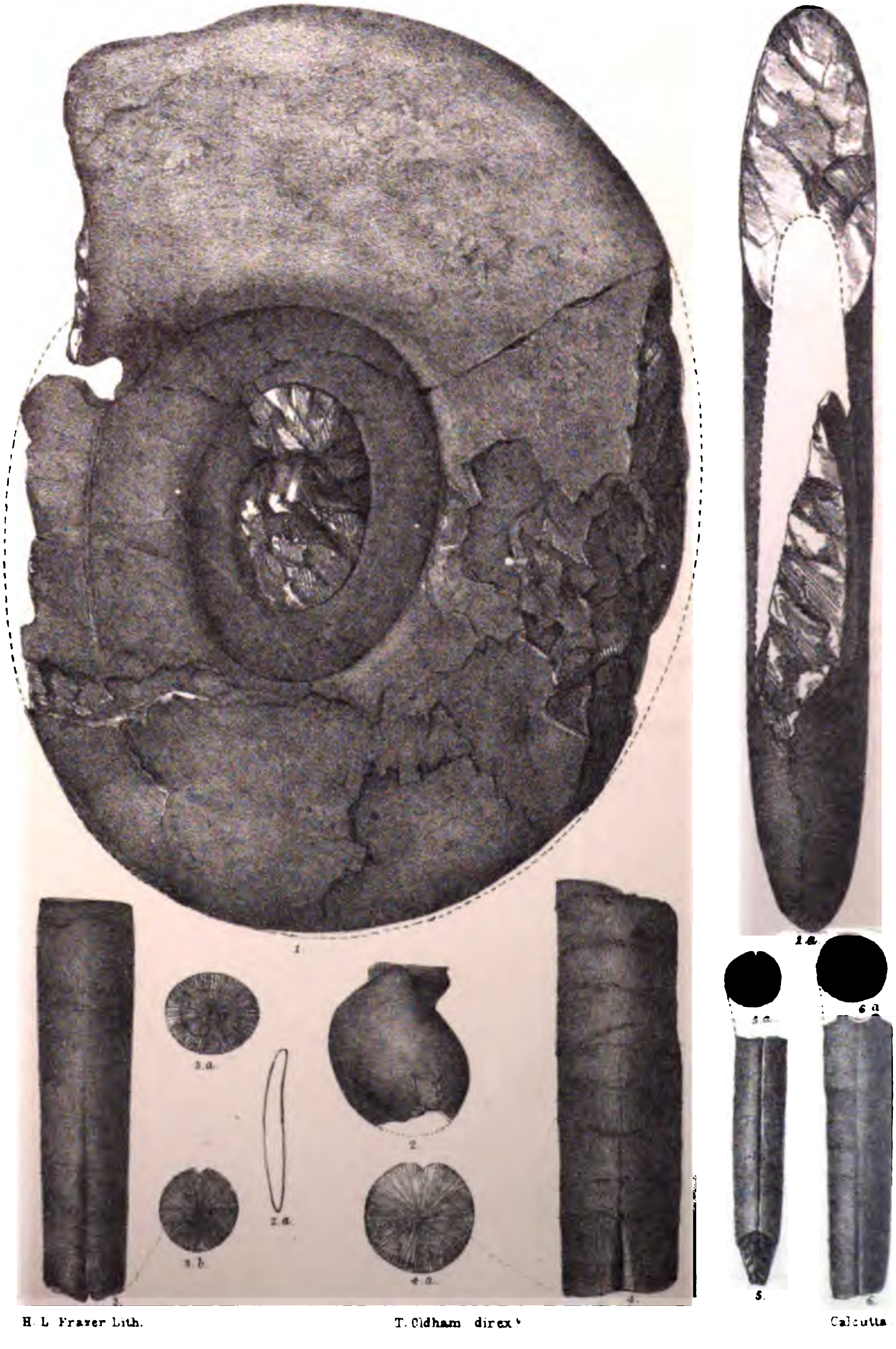

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PLATE VI.

Lilang Series.

FIG. 1. AMMONITES BATTENI, *Strachey*, p. 59, variety with compressed and high whorls, from Lilang.

Lower Tagling Limestone.

FIG. 2. AVICULA PUNCTATA, *Stoliczka*, p. 76. Fig 2*a*, shows the convexity of the shell; from the north of the Manirang pass.

FIGS. 3-6. BELEMNITES BUDHAICUS, *Stoliczka*, p. 78, views of different fragments of the same species; from the South of Gieumal.

All the specimens are in the Geological Survey collection.

W

H. L. Frazer lith:

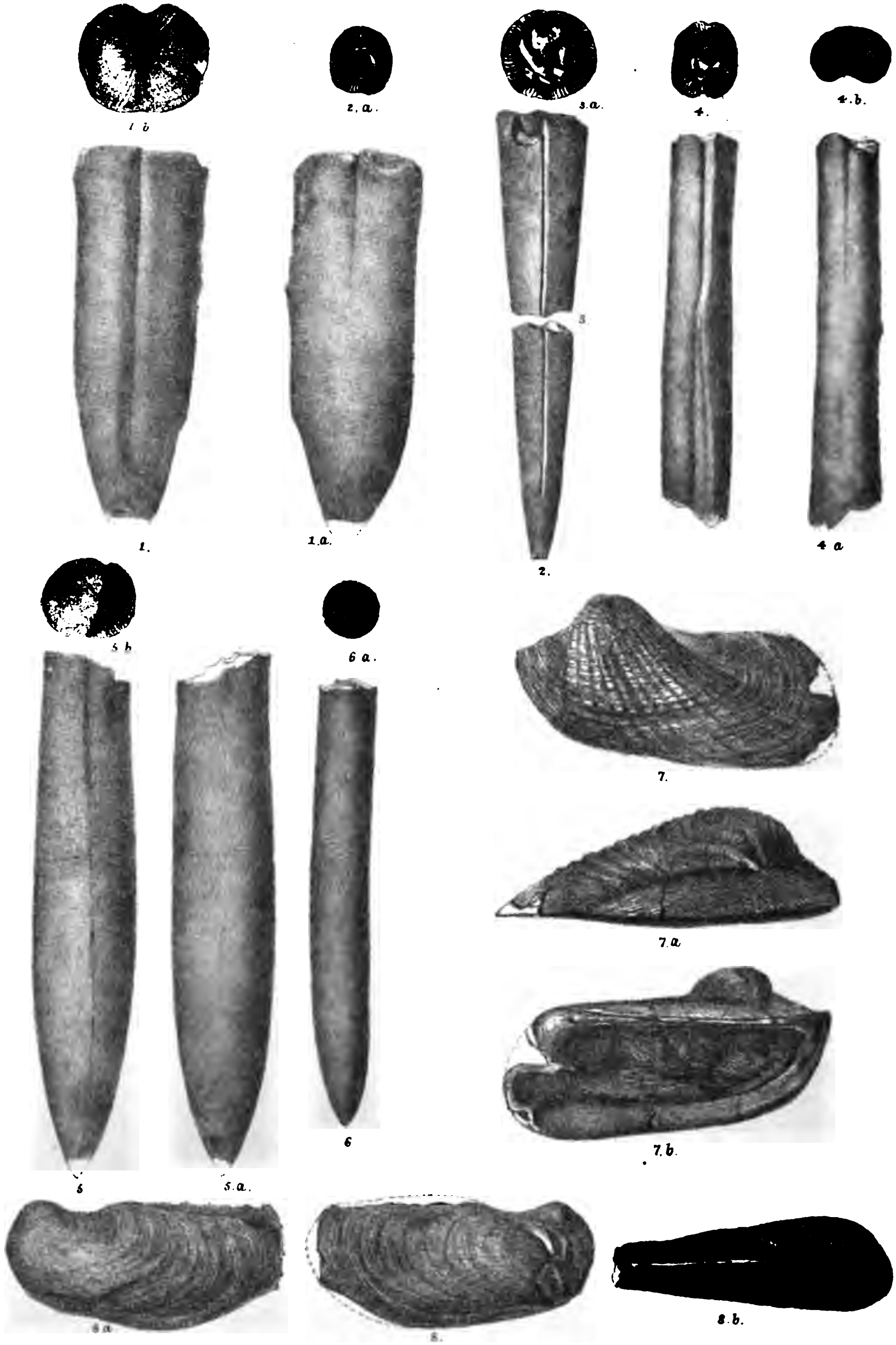
Calcutta.

PLATE VII.

Para Limestone.

FIG. 1. DICEROCARDIUM HIMALAYENSE, *Stoliczka*, p. 62, the apex of the right umbo has been restored from another specimen: from East of Hansi in North-Western Spiti.
Geological Survey collection.

Geol: Surv of India. *Stoliczka N. Western Himalaya* **Pl: VIII.**



H. L. Fraser Lith. T. Oldham direx[t] Calcutta.

PLATE VIII.

Lower Tagling Limestone.

FIGS. 1-4. BELEMNITES BISULCATUS, *Stoliczka*, p. 78, specimens of different size and variable sections; from the South-west of Gieumal.

FIGS. 5-6. BELEMNITES TIBETICUS, *Stoliczka*, p. 79. Figs. 5 and 5*a*, are front and back views of a large specimen; Fig. 6*a*, side view of a much thinner specimen without any trace of a furrow; from Gieumal.

Spiti Shales.

FIG. 7. MACRODON EGERTONIANUM, *Stoliczka*, p. 89. From Gieumal.

FIG. 8. AUCELLA LEGUMINOSA, *Stoliczka*, p. 88. Fig. 8 ventral, 8*a* back, 8*b* front, view; from the neighbourhood of Kibber.

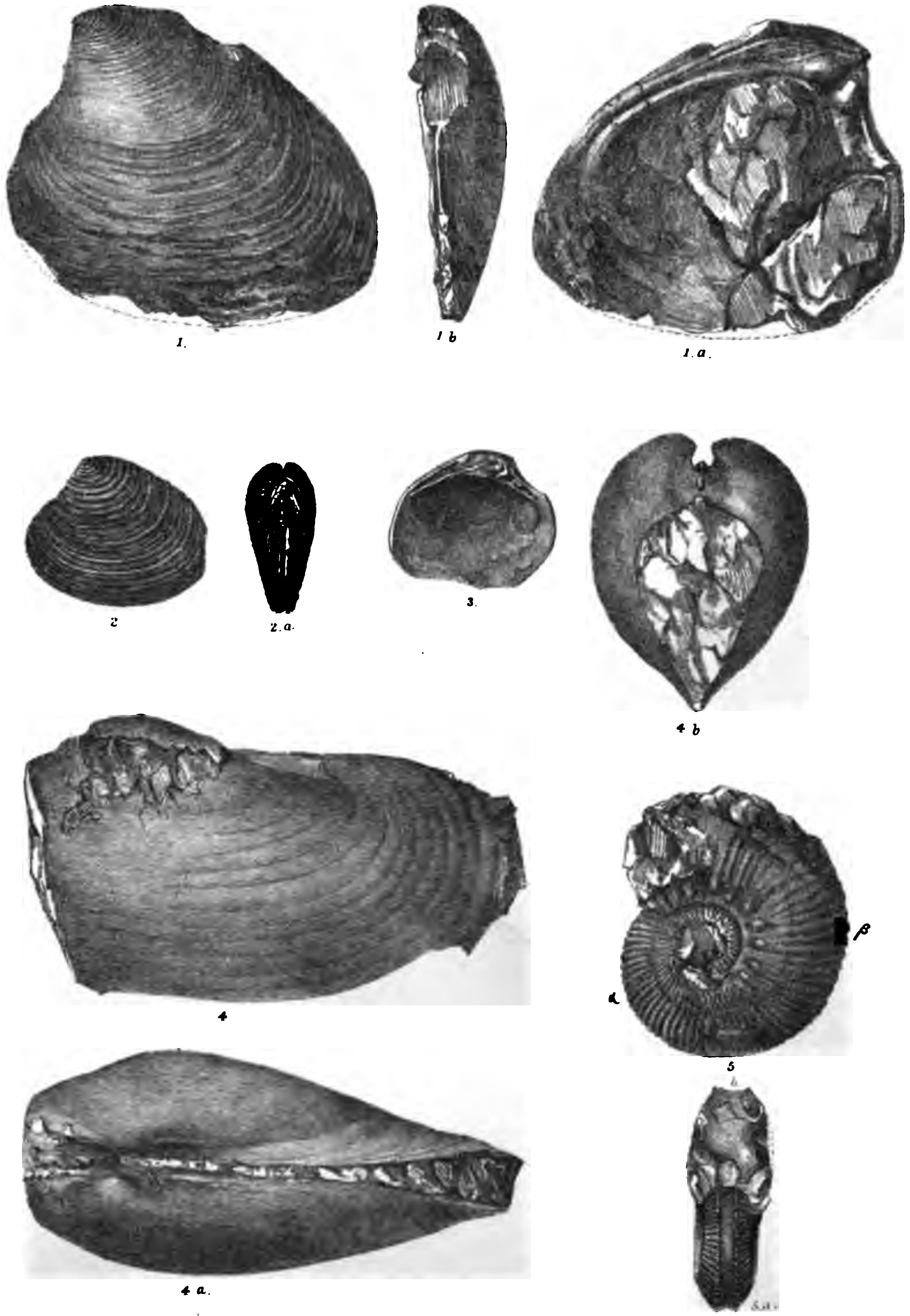


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PLATE IX.

Spiti Shales.

FIG. 1. ASTARTE SPITIENSIS, *Stoliczka*, p. 91, outer, side, and inner, views of the same shell; from the neighbourhood of Kibber.

FIG. 2. ASTARTE HIEMALIS, *Stoliczka*, p. 91, Fig. 2, 2*a*, side and front views of a small but perfect specimen: Fig. 3, inner view of another specimen; both are from the neighbourhood of Kibber.

FIG. 4. HOMOMYA TIBETICA, *Stoliczka*, p. 92, Fig. 4 side, 4*a* upper, and 4*b* frontal, view of a tolerably complete cast; from near Gieumal.

FIG. 5. AMMONITES THEODORII, *Oppel*, p. 99, Fig. 5, side view of a cast; Fig. 5*a* front view of a portion of it, a piece of the outer whorl having been broken away, to show the ornamentation on the inner volutions better. From Spiti, collected by Capt. Hutton.

N. B.—This figure is erroneously quoted on page 99 as Pl. IX. Fig. 4, instead of Pl. IX. Fig. 5.

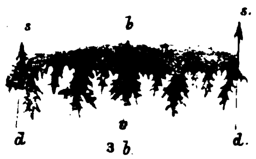
1

1. a

2.

1. b.

3 c.



3 b.

3.

3. a.

2 a.

4.

4. a.

H. L. Frazer Lith. T. Oldham direx.t Calcutta

PLATE X.

Spiti Shales.

FIG. 1. AMMONITES NIVALIS, *Stoliczka*, p. 106. Side and front views and outline of a septum of a specimen from Kibber.

FIG. 2. AMMONITES HYPHASIS, *Blanford*, p. 97, from near Gieumal.

FIG. 3. ANISOCERAS GERARDIANUM, *Stoliczka*, p. 110, from Spiti, collected by Capt. Hutton.

Gieumal Sandstone.

FIG. 4. ANATINA SPITIENSIS, *Stoliczka*, p. 115, inner view, and cast impression of the same specimen; from near Gieumal.

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

On the GYPSUM *of* LOWER SPITI, *with a list of* MINERALS *collected in the* HIMALAYAS, 1864, *by* F. R. MALLET, ESQ., *Geological Survey of India.*

OF the different observers who have visited lower Spiti few have omitted to notice the deposits of gypsum which occur there. The appearance of these is such that they can hardly fail to arrest the attention, and they form one of the many objects of interest in this valley.

As my own observations have led me to conclusions as to their origin and relations, different from those of my predecessors, whose writings I have seen, I have been led to pen the following short note regarding them.

Dr. Gerard, 1832.

Dr. Gerard (Observations on the Spiti valley, Asiatic Researches, Vol. XVIII) says, "the soil itself appears argillaceous, with beds of gravel, clay, and marle, deposits of gypsum, and a cineritious-looking rubble, indicating coal or plumbago."

Capt. Hutton, 1841.

Captain Hutton, who visited this region many years ago, refers to them, (Journal As. Soc. Bengal, Vol. X., p. 198, 1841,) and classes them with the alluvium, referring both to a salt lake, which he supposes at one time to have filled the entire valley, from whose waters the gypsum was chemically

deposited, "while the streams from the snows were bringing in large quantities of fine alluvial particles, such as sand and clay and water-worn stones of various sizes." He notices the fact of their being confined to the lower part of the valley.

Genl. Cunningham, 1844.

Genl. Cunningham also mentions that "about the junction of the Petti and Sutlej, the gneiss would seem to yield by degrees to limestone, slate, gypsum, and crystalline sandstone." (General Description of Kunawar, Journal As. Soc. Bengal, Vol. XIII., p. 175, 1844.)

Capt. Hay, 1850.

Capt. Hay (ibid, Vol. XIX., p. 434, 1850) also notices the occurrence of gypsum and alum, and states them to be "in connexion with the beds of red sandstone."

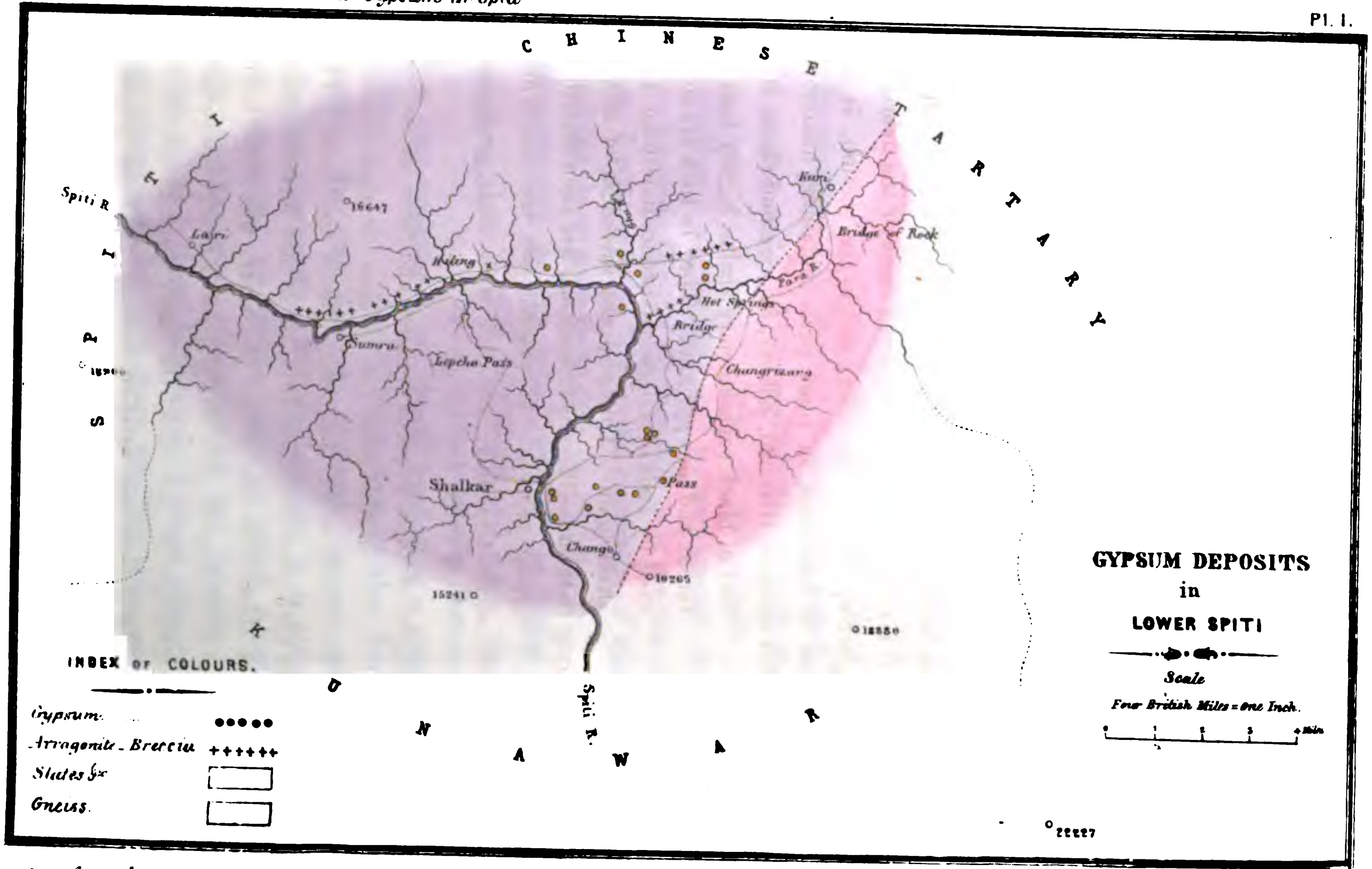
Geological relations.

These deposits appear, then, to have been generally classed either with the alluvium, or with the crystalline and older rocks of the district. From my own observations I am convinced they are unconnected *directly* with either, but as I believe they are dependent in their position and origin on the latter, I must mention briefly the succession of these rocks, before describing the gypsum itself.

General section.

Gneiss.

Commencing at the lower end of the valley we find gneiss east of Chango and Kuri. In mineral character it is more usually fine-grained and hard, often very quartzose; one variety containing a considerable proportion of black mica, another being without this mineral, the two forming alternate layers, giving the rock a banded appearance. Not uncommonly it is coarsely crystalline, and intersected by albitic veins in which schorl occurs plentifully, besides more rarely garnet and kyanite. The boundary of the gneiss is found between the Chinese village of Kuri, and the rock bridge close by, then down the Para river, and turning nearly south passes a little East of Chango. Resting on the gneiss is a



On transfer paper by Ballaram. Lith: by H.M. Smith, Surv. Genl's. Office, Calcutta Apr. 1865.

great thickness of highly pyritous dark grey and black slates, interstratified with pyritous quartzite and some limestone. These rocks are found nearly as far as Po; the beds north of the Para river appearing to be the same as those exposed in the stream at Lari. Here we see some 600 or 800 feet of hard black splintery slate, the lower part being speckled with innumerable minute cubes of pyrites. Higher up the crystals are fewer in number and larger in size, being often associated together in small concretions of the slates. The latter are covered by quartzites, also pyritous, and often honeycombed from the removal of this mineral; small crystals of it may also be found scattered through the debris of these rocks. Higher up, both in the valley and in the section, is an immense thickness of limestone, in some parts containing numerous fossils. Above this again at Gieumal, Kibber, &c., we find about 400 feet of black concretionary shales, highly fossiliferous and also pyritous. They in turn are covered by beds of yellow sandstone, limestone and shale again. This immense thickness of stratified rocks, belonging to several different formations, has been described in detail in the foregoing report. At present we are concerned with their mineral characters only, and not with their geological relations.

Dark pyritous slates.

Fossiliferous shales.

Limestone, &c.

Perhaps the largest of these gypseous masses, and from its position one of the most conspicuous, is that opposite Shalkar, on the other side of the Spiti. The slope of the hill is here very steep, and the deposit may be distinguished by its color, at about 600 feet above the river, the slope below being strewed with its fragments. The deposit is a large amorphous mass, resting on the face of the rock, the lower part concealed by breccia and talus. It is pure and massive, but by exposure becomes soft and partially disintegrated, so as to be easily cut by the knife.

Gypsum at Shalkar.

The unaltered rock is, however, of a snowy whiteness and crystalline texture, much resembling crystalline limestone, which it also nearly equals in hardness. Traversing the mass are a few small lenticular bands of compact dove-colored carbonate of lime. In front of the deposit, and partially covering the lower part, some breccia occurs, formed out of pieces of this limestone, with fragments of the stratified rocks on which the deposit rests, some clay, and large but coarse crystals of selenite which acts as the cement, the material of which has evidently been derived from the original deposit by solution. Close to this, and about 150 feet lower, a smaller mass is observable perched on the bare rock. No alluvium occurs in connexion with either of these, nor indeed on this portion of the slope. Alluvium is abundant on the Shalkar side of the river, but here I observed no gypsum. About 400 yards from the top of the pass between Changrizang and Chango on the Northern side a small deposit occurs, another having been previously met with lower down. Half a mile or so from the summit, on the Chango side, a larger mass is seen, another 300 yards further on, and two more occur between this and Chango. The first rests on pyritous slates, and the last two on the debris of these rocks, being themselves somewhat broken up and mixed with it. Another mass is met with between Chango and Shalkar. In mineral character they all resemble the deposit at the latter village, but no breccia occurs with them. On the road from Shalkar to the bridge over the Para river five or six masses are seen in a space of about 600 by 300 yards; I observed three others in different localities near the mouth of the Ghu stream, one about 800 feet above the Spiti. Again, between Huling and this stream, gypsum is met with, but this differs from the preceding in its mode of occurrence, as it appears to be *interstratified*

No alluvium.

At Chango pass,

rests on slates.

Near Huling,

with the slaty and quartzose beds, although it undoubtedly has no more connexion with them than a band of intrusive trap in a similar position, having evidently been deposited in an opening between the strata. It may be observed for some distance, being associated with crystalline carbonate of lime, which is almost undistinguishable from it in outward appearance.

appears interstratified.

From the various positions and modes of occurrence of these masses, it is at once evident that they do not belong to the older rocks of the valley, since they are all, with one exception, explained above, superficial; and it is equally clear that they have no connexion with the alluvium. If these masses had been chemically deposited from a large body of water in which strata were being formed mechanically at the same time, we should expect to find in them at least some traces of stratification, whereas none such exist, but the deposits are simply *amorphous masses.* How, if they had been formed in this way, could a mass occur between the beds of ancient stratified rock, or be mixed up with the angular debris, which is evidently of atmospheric origin? Moreover, there is no community of level between the different deposits, and they generally are found where there is *no* alluvium. They occur near the Spiti at Chango, and close to the top of the pass between this and Changrizang, a difference little short of 3,000 feet; and the latter locality is, if I mistake not, considerably above the highest level of any alluvium.

Position in all cases superficial.

If then they are not of lacustrine origin, there is but one other agent to account for them, namely, thermal springs, which account perfectly for their peculiarities of position, &c. Thermal springs may form such masses on the face of the older rocks, or between their strata, or amongst their debris, and the deposits will be unstratified and amorphous, and occur at any level.

Origin from thermal springs

Independently, however, of these considerations, which are of themselves I think sufficient to determine the origin of the gypsum, there is the additional fact tending still more strongly to confirm this opinion, that gypsum, with carbonate of lime, *is being deposited by thermal springs at the present time in this very region.*

Formation at present time,

On the right bank of the Para river, about 1½ miles from its mouth, we find the process going on. The water rises through the mass of gypsum and carbonate of lime into small pools formed by the natives for bathing, issuing at the surface with a temperature of 116°·5 F. The air around is strongly tainted by sulphuretted hydrogen which rises in bubbles through the water. By its decomposition it originates sulphur in a native state, which is found in microscopic crystals, or forming a film on the surface of the water. The calcareous deposit forms a large thick mass extending several yards along the river, and not less than 15 or 20 feet high; besides one or two smaller ones. At one end of it the carbonate of lime is seen in curved layers, from one to two inches thick, beneath which the white gypsum is exposed. On the hill side above a deposit occurs similar to those previously mentioned. At these springs, it will be observed, there is the same association of sulphate and carbonate of lime as in the deposits at Shalkar and near Huling.

near Para river.

In the same region, and, as I am inclined to believe, connected in origin with the gypsum, a rock may be observed, generally breccia, occasionally conglomerate, cemented by *arragonite*. The latter variety may be seen near the wooden bridge over the Para, the pebbles and boulders of gneiss, quartzite, slate, &c., forming the river alluvium being firmly united by this mineral. Loose talus and debris is similarly cemented into a breccia. It occurs at intervals from west of Sumra along the north

Breccia, Conglomerate.

side of the Spiti to Huling. The arragonite is usually radiated fibrous, rarely in small radiating crystals, and sometimes lining cavities in fibrous mammillary coats one or two inches thick. It is pure white, and opposite Sumra very good specimens of the mineral may be obtained. The rock is also seen along the road to Kuri above the hot springs, and probably occurs in many other places. Higher up the Spiti valley such debris often forms a breccia, but I have observed it cemented by arragonite only below Sumra.*

Gypsum all on slates.

The question of the original source whence the gypsum of these deposits has been derived receives elucidation from a fact observable on the accompanying map (Pl. I.) namely, that of the different masses which I have observed, about 20 in number, *all* are on the slaty rocks,—I have not seen one resting on the gneiss. There can scarcely therefore be any question that the mineral is derived from the slaty rocks, and its origin is undoubtedly to be attributed to the combination of iron pyrites and lime, which we find in these—a combination well known to produce this mineral; the bisulphide of iron by the action of air and moisture forming with the carbonate of lime hydrous sulphate of lime or gypsum, and carbonate of iron with free carbonic acid—$2\,(CaO,CO_2) + 4HO + FeS_2 + 7O = 2\,(CaO,SO_3 + 2HO) + FeO,CO_2 + CO$. The carbonate of iron is very prone, by oxidation, to pass into hydrous peroxide or limonite, and we very commonly find the small cubes of pyrites altered to the latter mineral either superficially or wholly. In the quartzite, as before remarked,

Formation of

Limonite.

* I observed one exception to this at Tshissigaong in upper Spiti, but here also the rock is associated with Gypsum, which occurs sparingly disseminated in crystals through the black shales above the limestone.

they are very frequently entirely removed, leaving the rock full of angular little cavities.*

The carbonic acid set free in this process may, I think, have been very probably the origin of the arragonite-breccia. Percolating with water through the calcareous strata, it exerted its dissolving action, and forming a solution of carbonate of lime, furnished the material with which the breccia and conglomerate are cemented. The amount of carbonic acid soluble in water being dependent on the temperature, and the amount of carbonate of lime on that of the carbonic acid, any increase in the temperature of the saturated solution must cause a deposition of carbonate of lime. As therefore the mean temperature decreases with the altitude,† the solution in percolating from any given elevation to one considerably lower must part with some of its lime, and this may be at least one way in which the arragonite has been formed.‡

Arragonite.

Another product of the decomposing pyrites is sulphate of magnesia, which, in many places, occurs plentifully as an efflorescence on the black slate; were it worth the trouble a considerable quantity might be procured annually by simple collection and by lixiviating the loose slate debris.

Epsomite.

* Two interesting papers on the occurrence of gypsum on the southern side of the Himalayas, by Capt. Herbert and Capt. Cautley, with remarks on the latter by the Rev. R. Everest, may be found in the Asiatic Researches, vol. XVIII, pt. I, p. 216, and Jour. Asiat. Soc. Bengal, vol. I, pp. 289 and 450. *On some points* their ideas as to the relations of these deposits are very similar to those expressed above with regard to the Spiti ones.

† Hooker (Himalayan Journals) gives the difference as 350 feet for 1° F. for elevations between 10,000 and 14,000 feet.

‡ If it be true that the formation of arragonite *under all circumstances* is due to high temperature of the solvent, this explanation would not suffice.

Limitation of area.

Why the gypseous deposits are confined to the region near the junction of the Para and Spiti, while the pyritous beds extend several miles higher up the valley, is explained by the fact that, although gypsum may be formed through the strata by decomposition, (as in the black shales at Tshissigaong, &c., and at the Niti Pass,) it cannot be collected and formed into *masses* without the agency of thermal springs, and it is simply necessary therefore to suppose that the latter have been always confined to nearly the same region as that in which they are found at present.

Hot springs without gypsum.

Hot springs occur on both banks of the Para within a few yards of each other, but while those on the right bank have formed the large calcareous masses before described, those on the left have produced none; the explanation of this probably being, that the latter rise through gneiss for the greater part of their course, and the former through the slates.

Former greater extent.

It appears then, that in former times thermal springs existed in this region, probably in greater numbers than at present, though it is very unlikely that all the gypseous masses were formed at one time. The same spring may have often ceased to flow in one place, and have subsequently broken out in another. Some may have been extinct for ages, while, as we have seen, in at least one locality, the mineral is still being formed at the present day. There is further proof of this, if I am right in referring the gypsum and arragonite to a common origin, for, at the wooden bridge over the Para, I observed pebbles of the former mineral in a conglomerate united with arragonite. The gypsum contemporaneous with this arragonite must be, therefore, of more recent date than that included in the conglomerate.

The compact unaltered portions of the gypsum are of a snowy whiteness, and would form a beautiful material for ornamental

purposes. All of it, from its apparent purity and freedom from iron, &c., might be manufactured into very superior plaster of Paris. One fatal bar, however, exists to its economic employment, namely, the mountain carriage across the entire breadth of the Himalayas. The existence of gypsum near the southern boundary of the hills makes it quite certain that these deposits could never be worked advantageously, at least for employment in India Proper.

List of Minerals collected in the Himalayas—June, September 1864.

Native Sulphur,—from Puga. This valley is situated between Lake Chomoriri and the Indus at an elevation of about 14,500 feet; two marches from Chomoriri and one from the river. The stream which drains it flows through a flat marshy plain, one to two miles wide. Some distance below the mines the valley contracts to a deep narrow gorge. At the mines the plain is about half a mile across; the hills on the south side, which are crossed on the route from Chomoriri, being formed of coarsely foliated orthoclase-gneiss, which becomes more schistose and schorlaceous near Puga. The hills on the north side of the valley are formed, in the lower part, of thinly foliated micaceous quartz-schist passing into mica-schist, and it is at the foot of the hill in this rock that the 'mines' are situated. Lower down the valley chlorite-schists and serpentine are met with.

The quartz-schist at the diggings is thinly foliated, greatly contorted on a small scale, and considerably altered locally by the agencies which have formed the sulphur and other minerals. It is intersected by many small clefts or fissures, and it is in these, and between the laminæ of the schist, that the chief portion of the sulphur is found. It frequently fills them completely in the massive form, but oftener it lines the opposite walls with a thick coating of small transparent crystals.

Gypsum occurs in large irregular masses through the schist. It has a finely saccharine appearance, but is dull, opaque, and rough to the touch, unlike the crystalline translucent mineral of Spiti. Crystals of sulphur are commonly disseminated through it, but the workable mineral is almost confined to the fissures of the schist. *Potash-alum* is also found here in veins one to two or three inches thick, but the quantity of it is small, and not sufficient to render it worth extraction. Still rarer is common white *opal*, which I only observed in one spot associated with gypsum.

The mines consist of vertical holes about eight feet deep, from the bottom of which the rock is excavated laterally for two or three yards. As the mineral is so near the surface, it is easier to open a new hole than to carry the lateral excavations further from the old one. If the latter plan were pursued, besides the greater heat and want of ventilation, artificial light would become necessary.

There are a dozen or more such holes extending along the foot of the hill, but only three or four were being worked when I was there, most of the others being abandoned and choked up with rubbish. The temperature inside is very high, almost oppressively so, which appears due to the copious hot springs rising close by, which must heat the surrounding rocks considerably.* The appearance of the interior is very pleasing from the contrast of the snowy gypsum with the brilliant sparkling crystals of yellow sulphur.

There can be little doubt that these minerals, like the gypsum of Spiti, have been formed by thermal springs; for besides their mode of occurrence through the fissures of the schist, the springs close by now

* These springs rise in the middle of the borax-grounds on the right bank of the stream, at temperatures from 135° to 178° F., the hottest being in a violent state of ebullition. The borax deposits are in themselves very interesting, but it is unnecessary to describe them here, as the subject has already been fully treated on by M. Marcadieu (" Selections from the Public Correspondence of the Punjab Administration," No. XII, Vol. II, 1855, where a map of the valley is given.)

deposit small quantities of sulphur at the surface. The principal mineral deposits are very probably below the surface. M. Marcadieu believes that sulphur is being formed at present in the mines from the vaporous condition, which appears by no means improbable.

There is no evidence to show from what chemical changes the gypsum, &c., have been derived; but from the difference in the association of the minerals here from those occurring with the gypsum of Spiti, these changes also would seem to have been of a somewhat different character. The rocks in the vicinity also differ from those in Spiti. Instead of the pyritous slates and quartzites of the latter region, the rocks at Puga are of the gneissose series.

The mines belong to the Maharajah of Kashmir, one of whose sepoys is on the spot in charge; but, as usual in such cases, he was not very communicative, or inclined to give much information on the subject. He informed me, however, that the annual yield of sulphur is about 500 or 600 maunds, but fluctuates much in different years. The amount depends chiefly on the weather. In this rigorous climate, at an elevation of 14,500 feet above the sea, where snow not unfrequently falls at midsummer, the work can only be carried on for four months in the year. The method of purification is exceedingly barbarous. Only the purest ore is used at all, the poorer portions being thrown away, so that round the mouths of all the excavations are heaps of refuse containing a large percentage of sulphur. The best parts are broken up small and melted in pots, the temperature being of course kept as low as possible to prevent ignition. The stony impurities are then skimmed off as they rise to the surface, generally carrying with them a coating of solidified sulphur, so that the secondary refuse heaps after the fusing are also rich in the mineral. The sulphur is poured from the pots into copper basin-shaped moulds, about 7 inches diameter and 2 inches deep, and the cakes removed when cold. The fuel comes from the lower end of the valley, where

clumps of scrubby trees border the stream in the deep sheltered gorge, into which the valley becomes narrowed. The supply appears to be abundant; much more than sufficient for the small requirements of the sulphur diggings. The existence of such firewood in the vicinity is extremely fortunate, in a district where trees or shrubs of any kind are almost unknown. It would be very easy to devise a simple mode of purification which would obviate the present great waste, and probably nearly double the yield of sulphur.

Stibnite.—Just west of the fine Bara-Shigri glacier in Lahoul, which descends from a lateral gorge into the bed of the Chandra river, sulphide of antimony occurs in the gneiss. I did not see the mineral *in situ*. A loose block close to the glacier, containing a large proportion of pure mineral, was fully 18 inches in the shortest direction, showing that the vein cannot be less than this in one part. An analysis by Mr. Tween gave, besides antimony and sulphur, some iron, alumina, lime and chlorine, with traces of copper and arsenic. Associated with the stibnite in small quantity are zinc-blende, iron pyrites, and carbonate of iron (manganiferous) more abundantly.

Captain Hay, Commissioner of Kulu, formerly obtained some of this antimony for trial. If the vein is generally as rich as the blocks I saw, the ore could, I should say, be profitably brought across the Hamta Pass and freed from gangue on the south side, where wood is abundant. This is two long, or three short, marches, with a made road for the greater part of the distance. The pass is about 14,500 feet high, and rather below the perpetual-snow line. From the forests on the south side to Sultanpur the capital of Kulu is four marches. There is no wood applicable to the purpose on the north side of the pass.

Galena.—(*a.*) Near the village of Uchich, two miles above Manikarn in Kulu, is an old mine now abandoned, which is known throughout the district as a 'Silver Mine.' I failed to detect any trace of silver however, the only minerals observable being iron pyrites, with

a very small quantity of galena and arsenical pyrites. The galena is scattered very sparingly through the gangue (quartz rock) in far too minute quantity to be of any practical value. The specimens of it I examined were not argentiferous. The mine is in the form of a narrow vertical fissure 2 or 3 feet wide, accessible by two small entrances in the face of the precipitous cliff, and extending inwards for a few fathoms. Some silver may possibly have been found here formerly, which is now exhausted, but more probably the proprietor of the mine was misled by the silvery appearance of the galena.

(*b.*) A loose pebble from the bed of the Sutlej below Rampur—highly garnetiferous quartzose chlorite-schist with some galena.

Zinc-blende.—The ordinary dark brown opaque variety occurs sparingly disseminated through the gangue of the antimony at Bara Shigri.

Iron Pyrites.—(*a*). 200 to 400 feet above the Blini limestone at Simla some black shale occurs beneath quartzite. The shale is usually somewhat pyritous, and the mineral is occasionally found in small seams. By its decomposition alum is formed as an efflorescence on the shales.

(*b.*) From near Muttianna, where it is occasionally seen in chloritic schistose beds.

(*c.*) From the black slates of lower Spiti (p. 155).

Fluor-Spar.—A light green variety occurs very rarely amongst the minerals of the albite-granite veins at Wangtu Bridge (p. 12).

Chromic Iron.—Amongst the loose stones and debris scattered over the comparatively level ground bordering the Hanle-chu (river) pieces of chromic iron are not difficult to find in some places. The mineral generally has a more or less crystalline structure, sometimes largely so: Sp. Gr. = 4·208. I did not observe the ore *in situ*, but there can be no doubt of the pieces having been derived from the serpentinous rocks, which form much of the hills on either side, especially

on the west. Serpentine being the ordinary rock in which chromate of iron occurs, one would be pretty certain to find the mineral *in situ* by a little search through these beds. That it occurs in some quantity is probable from the size one sometimes sees scattered pieces. In the wall of the Hanle monastery I observed a cuboidal block 8 or 9 inches square. The same serpentine rocks occur in the lower part of the Puga valley 40 miles north-west of Hanle. I observed no chromate of iron here, though it may very likely exist.

Some specimens of the chromic iron are traversed by extremely thin seams of another chromic mineral, which outwardly much resembles Ouvarovite, but differs from it in composition. The chromate of iron has a slight tendency to break along these seams, both sides of which are then seen coated with very minute crystals of a brilliant emerald green color. Viewed under the microscope the faces of the crystals appear to resemble those of a rhombic dodecahedron. This is the form of Ouvarovite which also resembles the mineral in question in its action before the blowpipe. Both are found with chromic iron. Ouvarovite, however, differs considerably in composition and also in hardness ; (*a*) is an analysis of it by Komonen,* (*b*) one of the mineral in question by Mr. Tween.

(*a*)		(*b*)	
Silica	37·11	Silica	41·2
Oxide of chrome ...	22·54	Oxide of chrome ...	33·5
Alumina	5·88	Alumina ...	
Protoxide of Iron ...	2·44	Oxide of Iron	24·2
Magnesia	1·10	Magnesia ...	
Lime	30·34	Water...	1·1
Water	1·01		

In Ouvarovite the alumina replaces part of the chrome, the iron and magnesia replacing part of the lime. In (*b*) there is no lime, but the

* Phillips' Mineralogy by Brooke and Miller.

quantity of iron and magnesia is much greater. With regard also to the analysis (*b*) it should be mentioned, that the quantity of the mineral available for examination was so extremely minute as to render a quantitative determination very uncertain.

Micaceous Iron is occasionally met with in quartzite between Rampur and Gaora (p. 11) in thin seams parallel to the bedding. It also occurs similarly in quartzite below Manikarn.

Opal.—A common white variety, nearly opaque and of a porcellanic appearance, occurs with the gypsum and sulphur of Puga. It is the rarest of the minerals found there, having been seen in only one spot.

Diallage.—This variety of pyroxene occurs plentifully in the serpentine of the Hanle and Puga valleys. Loose blocks of the mineral, two and three feet diameter, are sometimes seen. It varies in colour from light to dark green, the principal cleavage planes having a brilliant pearly-metallic lustre. Diallage is also frequently disseminated in small crystals through the serpentine.

Hornblende.—In the bed of the Puga stream some distance from its mouth, amongst many other varieties of rocks, loose pieces of a binary compound occur, the base being felspathic, and traversed in every direction by long bladed crystals of dark green hornblende. This rock probably forms veins through the serpentine and chloritic beds of the vicinity.

Beryl is occasionally found in the albite-granite veins which traverse the gneiss at Wangtu bridge, and for some miles up the Sutlej and Wangur Rivers (p. 12); also in the similar veins of the Chandra valley above the Hamta Pass. The crystals are generally light blue, but only translucent, and so flawed as to be unfit for jewelry. They are usually small, the largest specimen of beryl from these localities that I am aware of, being one obtained by Mr. Theobald in 1861 a few miles above Wangtu bridge. This crystal (now in the Geological Survey Museum) is about 3½ inches long and ¾ inch diameter. The

mineral appears confined to those parts of the rock in which tourmaline occurs, though the latter often abounds without any beryl accompanying it.

Garnet.—(*a.*)—The mica-schist of Jatog near Simla is highly garnetiferous, and by its weathering the crystals are set free in large numbers. In this way the roads which pass over this rock are thickly strewn with small garnets ; all are of the same form—a dodecahedron with truncated edges. (*b.*)—From the talcose schist between Gaora and Serahan, associated with staurotide. It occurs in dodecahedrons with polished faces and often very regular form. The edges are sometimes truncated, but this is exceptional. (*c.*)—From the gneiss north-east of Shalkar.

Epidote with felspar occurs in small irregular veins through the chlorite schists of the Puga and Hanle valleys, being well seen near the Hanle monastery. The epidote is usually granular, sometimes columnar, the crystals penetrating the felspar.

Muscovite.—The mica in the granite veins at Wangtu bridge is never intimately blended with the other minerals, but is generally scattered through the rock in individual crystals of some size. The largest plates are 5 or 6 inches diameter and 1 or 2 thick. In these, however, the form of the crystal is not so well defined as in some smaller ones. Some plates show by transmitted light portions of a series of concentric hexagons, the sides of which are parallel to those of the crystal. The colour is usually brown, rarely silvery white.

Uniaxial Mica.—Between Serahan and Tranda very dark brown uniaxial mica, with silvery flakes of muscovite through it, often occurs as a scaly aggregate, in layers through the micaceous strata (p. 11). Notwithstanding its uniaxial character it is not acted on by sulphuric acid.

Albite.—The granite veins at Wangtu are mainly composed of albite, and large cleavable masses of the mineral are seen unmixed

with any other. The colour is pure white; translucent, or in thin plates often semi-transparent (p. 12).

Very similar in mineral character are the veins which traverse the gneiss of the Chandra valley above the Hamta Pass. These vary in breadth from several feet to the fraction of an inch. The proportion of quartz and mica is usually small, the former sometimes occurring in transparent crystals. The mica is not found in as large plates as at Wangtu. Beryl is rare in these veins. Small garnets and black tourmaline common. The latter mineral appears to be generally more abundant in albitic crystalline rocks than in those containing orthoclase, and I have found beryl *only* in the former variety.

The veins of the Chandra valley traverse the gneiss in different directions, and in some places those *transverse* to the foliation (Fig. 1. Pl. II.) are reduplicated in a very remarkable manner, while those parallel to it (*b*) are quite free from contortion. These appearances at once suggest great pressure and squeezing in a direction more or less perpendicular to the foliation, and although the hypothesis is not without difficulties, the reduplications must apparently be accounted for in this manner. The veins must have been intruded either in their present form, or else comparatively straight. In the former case it is necessary to suppose the gneiss previously traversed by numerous fissures, or at least lines of weakness, of this peculiar reduplicated form, but it seems quite impossible to imagine any cause by which such could have been produced. If the veins then were not intruded in their present form, they *could* only have obtained it by subsequent pressure. It is observable that they are generally thickened at the bends (Fig. 1*a*, Pl. II.); an evident result of such force, which would tend to squeeze the veins thinner where perpendicular to its direction; and where parallel to it (*bb*) to thicken them by lateral expansion. The veins lying perpendicular to the direction of pressure would of course be liable to no contortion.

Fig. 1.

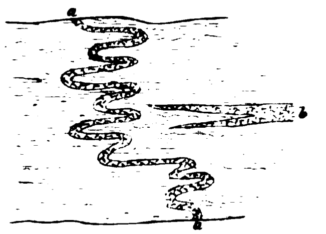


Fig. 1a.

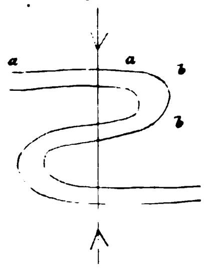


Fig. 2.

The shaded portion is Quartz.

black „ „ *Schorl.*

LITH: BY H. M. SMITH, SURV. GENL'S OFFICE, CALCUTTA, JULY 865.

Orthoclase.—From the porphyritic gneiss of the Jubburseesa Pass north of Lake Kiagr. It occurs through the rock in masses several inches diameter, but well formed crystals seldom exceed 2 or 3 inches in length (p. 127).

Staurotide occurs in small crystals, and sparingly, in the garnetiferous talc schists between Gaora and Serahan.

Kyanite.—From the gneiss above Yangpa. For some miles beyond this village towards the Bhabeh Pass, kyanite constitutes a regular ingredient of the gneiss in some parts of limited extent, being sometimes associated with small garnets. The kyanite occurs in the ordinary light-blue bladed prisms; rarely white and fibrous.

Tourmaline is found abundantly in the granite veins at Wangtu bridge, besides being diffused less freely through the gneiss itself. Indeed in many parts of the hills tourmaline may be regarded as a constituent of the gneiss rather than as an accidental mineral. It occurs in the gneiss north-east of Shalkar and of the Chandra valley. I have never observed any other variety, however, than ordinary schorl. Many of the prisms from Wangtu contain an admixture of quartz arranged more or less symmetrically. In these there is usually a central nucleus of pure tourmaline, around which are arranged alternate plates of tourmaline and quartz in planes radiating from the centre of the crystal. An example of this structure, which seems similar to that by which the foreign matter in chiastolite and some other minerals acquires a symmetrical arrangement, is shown in Fig. 2. Pl. II. (natural size).

The granite veins of the Chandra valley also contain a large amount of tourmaline. It occurs chiefly in the albite, even when quartz forms a prominent ingredient of the vein, which is not common. It is usually met with in long three-sided prisms, the sides often curved, or flat with bevelled angles. The termination is commonly a plain three-sided pyramid. The prisms are very commonly arranged in one direction, lying nearly parallel to each other, and this direction is perpendicular

to the sides of the vein. The crystals are larger and more abundant near the sides than in the centre. I observed in one or two places pseudomorphs of mica after tourmaline, one portion of a prism being sometimes unaltered, while the remainder was completely changed to this mineral, the plates lying parallel to the length of the prism.

Talc.—Between Rampur and Gaora the talcose schist (p. 11) contains occasional bands of very pure white quartzite, between the beds of which white and greenish talc often occurs in lenticular seams from 1 to 3 inches thick.

Serpentine.—Serpentine rock is associated with chlorite schists in the lower part of the Puga valley and in the Hanle valley below the monastery, the beds being the same in both cases. The ordinary rock is very dark green and massive, and is traversed by thin seams of a finer variety, which is frequently foliated and sometimes of a bright yellowish green color.*

Gypsum.—(*a*)—From the hot springs at Changrizang (p.158). (*b*)—From a deposit on the hill side above these springs (p. 158). (*c*)—Selenite from breccia near Shalkar (p. 156). (*d*)—From the sulphur mines at Puga (p. 163).

Alum.—(*a*)—From the sulphur mines at Puga (p. 163). (*b*)—From near Simla (p. 166).

Epsomite.—From lower Spiti (p. 160).

Borax.—From the borax grounds at Puga (p. 163).

Calcite.—From the limestone of Jatog near Simla, where it occurs in veins through the rock, and is used for making lime. Similar veins traverse the limestone of the Krol.

Spathic Iron.—From Bara Shigri (p. 165).

Arragonite—From lower Spiti (p. 158).

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* Besides the minerals previously mentioned as occurring in the serpentine, thin seams of a white carbonate sometimes fill the joint-cracks, not improbably *magnesite*; but the specimens were lost before an opportunity of examining them occurred.

The labours of the Geological Survey of India were extended to the Presidency of Bombay about three years since, and a small party formed there, and placed under the charge of Wm. T. Blanford, Esq., F. G. S.

The following brief description of the structure of the Island of Bombay, prepared under Mr. Blanford's direction, is the first of a series relating to Western India, which will appear from time to time.

THOMAS OLDHAM,
Superintendent of the Geological
Survey of India.

Calcutta, April 1866.

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

On the Geology of the Island of BOMBAY, *by* A. B. WYNNE, F. G. S., &c.,
Geological Survey of India.

CONTENTS.

1.—INTRODUCTION.

The geological structure of Bombay Island, although closely allied to that of the neighbouring coast and other portions of Western India, presents local differences of considerable interest which have already attracted the attention of members of the Bombay Scientific Societies and of other observers.

Previous observers.

Several papers have appeared as the results of their investigations,* the writers having left little to be added to the details already collected save what can be gathered from excavations subsequently made. As, however, all these

* The two most comprehensive of these papers will be found reprinted, and the rest alluded to, in "Papers on the Geology of Western India", edited by Dr. Carter for Government, and published in Bombay, in 1857.

papers contain accurate descriptions of the details rather than correct conclusions with regard to the arrangement of the rocks and the structural geology of the district, it will be well before proceeding further to notice briefly each writer's views.

Dr. Thompson, 1836.

The earliest of these papers to which access could be obtained is a "Sketch of the geology of the Bombay Islands," by Robt. D. Thompson, M. D., (Madras Journal of Literature and Science, 1836, Vol. V, page 159.)

The author commences by briefly describing the meteorology and physical geography of the islands around Bombay; then proceeds to enumerate the varieties of rocks found on them, and the simple minerals occurring in the same rocks. He next furnishes a separate sketch of the geology of each island, and concludes with general observations upon the configuration of the western coast. In the description of Bombay Island some of the kinds of rock occurring in different localities are noticed, but very little is said of their relations to each other; and the author classes the whole broadly as claystone-porphyry, and amygdaloid, with basalt appearing in places, as on Malabar Hill, each rock admitting of considerable variation in the amounts of the constituent minerals. At page 165 he mentions the approximate similarity of the hard close-grained rock of Baboola Tank to "greenstone, as it appears sometimes in Scotland with the aspect of an aqueous deposit." The paper is somewhat discursive, and many matters not directly connected with Geology are discussed.

Dr. Lush, 1836.

In a paper entitled 'Geological notes on the northern Conkan, &c.,' (published in the Journal of the Asiatic Society of Bengal; December 1836, Vol. V., p. 761), Doctor C. Lush gives a passing notice of Bombay. He speaks of "horizontal strata of sandstone containing shells" obviously the 'littoral concrete' of later writers and justly concludes that these beds are above the trap rocks.

Next in order of time is a paper by G. T. Clark, Esq., C. E., (Quarterly Journal of the Geological Society, London, Vol. III, page 221, January, 1847). The opening paragraph contains the nearest approach to the true state of the case to be found in any of the papers which we have seen, so far as structural arrangement is concerned. It is as follows :—"The Island of Bombay is composed of five or six bands of trap rock, chiefly greenstone and amygdaloid, conformably dipping west at about 10° or 15°, and separated by beds that have the appearance of being of sedimentary origin, though there is no actual proof of the fact." Since this was written abundant evidence to prove the intervening beds to be of sedimentary origin has been found. Of their appearance or exposure at that time of course nothing can be stated here, but it seems strange that so accurate an observer, as the first part of this paragraph proves Mr. Clark to have been, should have made the reservation contained in the concluding lines.

G. T. Clark, 1847.

The chief portion of this paper refers not to the Island of Bombay itself, but to the Konkan and Deccan, parts of the main-land at considerable distances from Bombay.

After these papers come several communications to the Bombay Geographical Society, the Bengal Asiatic Society, and the British Association for the advancement of Science,—the results of Dr. Buist's exertions,—all which appear to have been subsequently combined in his paper "on the geology of the Island of Bombay." (Transactions, Bombay Geographical Society, 1851, Vol. X, page 167.)

Dr. Buist, 1851.

In this paper the position and physical features of the Island; the various kinds of rocks, clays, soils, the supplies of water, and the evidences of elevation and depression in recent times, are treated of: the author confining himself chiefly to descriptions of observed facts, and leaving his

conclusions with regard to the geological sequence of the different rocks in a great degree to be inferred indirectly from what he states.

It would appear from the manner in which the 'sedimentary beds' of Mr. Clark are described,—their being called 'fresh-water beds' and stated to alternate with the traps,—*that the author agreed with Mr. Clark as to the general structure of the Island; but this is not prominently put forward. Each side of the Island is separately described in detail, and the centre has a section devoted to itself. We do not find it stated that the same rocks occur at both sides of the Island. The traps are mentioned as basalt, greenstone, porphyry, amygdaloid, and trap-tuffa; the clays and other superficial deposits are treated of at length, and all the rocks of the Island are minutely described. The evidence regarding recent upheaval and depression of the district is considered, (at least one recent elevation of Bombay being proved,) and lastly, there are sections upon 'supplies of water,' and upon 'papers upon the geology of Bombay' which had previously appeared.

As to matters of fact and detail this is a valuable paper, there being but few points in it to which objection can be made, while the amount of information it conveys is very large.

Dr. H. J. Carter, 1862.

At about the same period, although bearing a somewhat later date, we have Dr. Carter's paper ('Geology of the Island of Bombay, with a geological map and plates.' Journal Bomb. Bran. Royal Asiatic Society, July 1862, Vol. IV., page 161: read December 1850.) This, although in a different way, is even a more elaborate and exhaustive treatise than that of Dr. Buist. The details are somewhat more generalized as regards localities, while the composition of the rocks is more minutely treated of.

* Dr. Buist is unquestionably correct in this opinion. He mentions(page 189, Geological Papers on Western India,) his conviction that there are at least six deposits of sedimentary matter cropping out between Lovegrove and Sewree, (a distance of five miles).

And a large portion of the paper is occupied by descriptions of the fossils found in the "fresh-water beds."

The paper opens with a summary containing assertions sought to be established throughout regarding the arrangement and sub-division into periods of the various rocks to be found in the Island. According to the author these sub-divisions are four; the first representing whatever the base of the Island rests upon; the second, including the fresh-water formation, is referred to as an accumulation deposited by a lake or river horizontally all over the Island of Bombay, afterwards covered over by a sheet of basalt, and later still intruded into and broken up by other igneous rocks. These igneous rocks form the author's third period, and they are again sub-divided into four 'effusions,' each of which is traced in its various exposures throughout the Island. All igneous rocks seen are assigned to one or other of these 'effusions.' The fourth period is represented by the 'marine formation,' consisting of recent deposits of clay, calcareous 'littoral concrete,' &c.

Nomenclature adopted by Dr. Carter.

After this summary the author enters upon a detailed description of the geography and geology of the Island, adopting in the lithological portions of his paper the classification of M. Alexandre Brongniart, as given in the *Dictionnaire des Sciences Naturelles*, under the article *Roches*.

The rocks, with the exception of the fresh-water strata, are all stated to be volcanic, belonging to the trappean system, and the names trappite,* basalt, trappito-basalt, aphanite, spilite, amygdaloid, and volcanic breccia, are used as distinctive terms.

The trappite is stated to occur on both sides of the Island, to have once in all probability extended across it, and to be traceable throughout its whole length except at the northern end. It is looked upon

* In the first edition of Dr. Carter's paper the trappite was called diorite.

as one mass whose upper part is more crystalline and tough than that beneath; 'its structure sometimes almost assuming the form of the Bombay basalt,' and it is supposed to have overflowed a plain formed by the fresh water strata over the whole Island. The basalt of Bombay is included within the same period as this trappite under the name of 'trappito-basaltic tract,' and is considered part of one and the same formation.

As next in succession below this trappite the fresh-water beds are then considered, and the author, viewing them as one horizontally extended and undivided group, having, however, a slight anticlinal curvature beneath Malabar Hill, gives a minutely detailed description of their mode of occurrence at the sluices (Lovegrove), where, he says, they are least disturbed and best seen. In connexion with this portion of the paper is the very full description of the fossils found in these beds by Dr. Leith and by the author.

Following the description of the fresh-water beds is that of the 'second volcanic effusion,' which is stated to have flowed in between, and to have broken up, the aqueous strata, but it is not supposed to have penetrated the overlying trappito-basalt. It is said to appear in many parts of the Island and to assume a variety of forms, from one hardly recognisable as different from the trappite, through various kinds of amygdaloid, aphanite, spilite, white trap, vesicular rock containing geodes of quartz crystals, to massive varieties which have lost their crystalline appearance and have assumed a compact structure 'opaque, white, and greasy to the nail.' It is looked upon as the agent by which the ridges of the island have been elevated, and the two foregoing subdivisions disturbed and displaced.

The third volcanic effusion is then described as having broken up and converted the fresh-water strata and other rocks into a volcanic breccia. It also is stated to have many varieties, passing from white powdery

aphanite and light colored soft earthy or sandy (? decomposed) rock to a hard black jaspideous or chertified variety. It is frequently red or mottled, and large fragments of the fresh-water beds are said to be enclosed in it. This third effusion is stated to be penetrated by dykes of another and newer rock of the same kind belonging to a fourth effusion. In connection with this subject the author gives his opinion that the third effusion is contemporaneous with the laterite formations and in some places identical with them, and to establish this, he reviews the descriptions of laterite given by Dr. Buchanan, Dr. Christie, Mr. B. Babington, Dr. Voysey, Mr. Cole, Mr. Coulthard, Captain Newbold, and Dr. McClelland, comparing these with his own observations, stating the difference between the breccia of this 'effusion' and genuine laterite, and arguing that the latter must extend further north than was previously supposed.

The author then passes to the consideration of the newer formations, describing the clay, shell-concrete, and blown sand of the central and littoral portions of the Island, and after some practical observations upon the building stone, lime, sand, wells, and coaly portions of the fossiliferous strata, concludes his paper with a list of rock specimens, minerals, and fossils presented to the Bombay Asiatic Society by himself and Dr. Leith and an explanation of the map and plates to illustrate his paper. From the above sketch it will be seen that this is a very comprehensive and elaborate paper, in which strong conclusions are arrived at and copious details given.

Many of the author's observations are supported by an examination of the ground, and although most of his details are accurate and have been collected with much care, certain of his deductions, and particularly those bearing upon the generalized view of the geology of the Island, appear to be untenable.

At the outset the fact, that the Island is formed of a series of beds dipping to the west, as observed by Mr. G. Clark, seems to have

entirely escaped Dr. Carter's attention, although he notices one of the consequences of this structure in the shape of the ridges and in their scarped sides being to the east, while all their longer slopes are presented to the west. Again, although the rocks are superimposed upon each other almost in the order in which he places them, we have not been able to discover any evidence for their sub-division into his four groups, nor yet for any of these having been erupted *within* the limits of the island, and consequently we are unable to admit the conclusion that the hills of this district have been elevated by the force of *local* intrusions of igneous rock beneath them. Neither can we agree with the statement that the fresh-water strata, or shale series, existed as but one continuous horizontal and undivided group forming a plain, resting upon which a sheet of trap stretched across the Island from side to side.

As the strata of which Bombay Island is mainly composed all incline to the west, and other rocks of the series intervene between the bands of shale, a series of step-faults along the strike, causing repetitions of the same beds at the surface where the shales are now found, would be necessary to establish Dr. Carter's conclusion; but there is no visible evidence to warrant the supposition that faults of the kind exist, or that the various shale exposures are different portions of a single group.

In the mineralogical and lithological parts of the paper certain minute distinctions are made between varieties of the rocks; while more striking varieties which are even prominently mentioned have been included together in classifying or in tracing out one or other of the 'effusions:' these variations being attributed to local causes in connexion with each irruption supposed to have taken place within the area now occupied by the Island of Bombay.

Although the author's general deductions seem to have been vitiated by his having overlooked the true stratigraphical relations of the rocks, the paper is still valuable as a record of geological observations.

Having thus briefly alluded to such publications treating of the geology of Bombay as could be consulted, and having expressed our dissent from some of Dr. Carter's deductions, we shall proceed to explain the geological facts as represented upon the accompanying map, Plate I and Sections, Plate II; with less detail, however, than would have been necessary had not the authors of the papers noticed above already treated the subject as fully as they have done.

2.—General Description of the ground.

The Island of Bombay, upon which the city of the same name is situated, is one of a picturesque group on the western coast of Hindoostan crossed by the 19th parallel of north latitude, which passes over the Island of Bombay. This group, including the larger and more lofty Islands of Salsette and Trombay, divided by but narrow tidal creeks from each other and from the shore, is so situated as to embrace between it and the main land the beautiful and spacious harbour, which has a width varying from five to seven miles. The conspicuous Island of Elephanta, famous for its cave temples, lies entirely within the harbour; and many other detached islets complete the group.

Several of the neighbouring Islands have higher elevations than that of Bombay, within which only small ridges and chains of hills varying in height from 85 to 180 feet* occur. The eminences around Bombay, however, command splendid views of the extensive harbour, with its hilly Islands backed by the long mural ranges and here and there peculiarly pinnacled summits of the Ghâts, while the adjacent Islands, with portions of the main land separated by narrow belts of water, present beautiful examples of rugged and rocky scenery frequently covered with jungle and brushwood down to the water's edge, and there bordered by mangrove bushes and lofty palms.

United to Bombay by causeways are the two small Colaba Islands to the south, and other causeways connect Bombay with Salsette to the North. Including the former the Island of Bombay extends in a direction a little east of north and west of south to a length of about 11½ miles on the landward side, 6 on the western or seaward side, and has a width of about 3 miles at the broadest part, containing a calculated area of a little more than 16 square miles.†

* These heights are taken from "Papers on the Geology of Western India" before referred to.

† These distances are from the Atlas Sheet No. 25; the area from information kindly afforded by Dr. Leith.

Description of the ground in connection with its geology.—Such features as the ground presents are (like those of most other places) the results of denudation; they consist of the previously mentioned ridges extending along and determining the direction of the Island; the best defined is that of Malabar Hill, forming the Island's "western sea-wall," projecting to the south as Malabar Point, broken through completely midway, at the Vallade, and running into the sea again at its northern end, where it terminates in Wurlee Point. Its greatest height is stated to be 180 feet.—*(Dr. Carter.)*

Hill ridges.

The other ridges or chains of hills stretch along the eastern side of the Island, leaving its centre entirely occupied by a level plain; they commence at Nowrojee Hill close to the city, and extend northwards in parallel directions, but otherwise irregularly, with heights of 160 feet and less, by Mazagaon, Chinchpooglee, and Antop Hill, towards Sion, where their resemblance to ridges ceases, and they become merely a cluster of hills. Although not possessing any very conspicuous physical features, the hills rise sharply upon one side, and with a somewhat more gentle slope upon the other, from the muddy shores at the Island's northern extremity and eastern side, or from the level flat which stretches through it from end to end, gaining by contrast much of what they want in elevation. The longer and more gentle slopes of all the ridges are presented to the west, while their steeper sides and cliffs face to the east; a character well seen in Malabar Hill. It may be observed also that each of these long slopes is mainly formed of one kind of rock, and on closer examination planes of stratification will be found coinciding in a general way with the western surfaces of the hills, that is, having a more or less westerly dip. Further, upon crossing the Island and these planes of stratification at right angles, we find that varieties occur amongst the

Westerly dip.

rocks; the basalt of Malabar ridge differs from the traps of the eastern hills, and between the two a totally different set of shaly rocks occurs, the general dip of which is also to the west.

Among the eastern hills again, and always extending along their length, varieties of trappean rocks appear, and here again smaller bands of shale recur, while the most easterly variety of rock is different from all the rest, and may be traced at intervals, for miles, parallel to the general strike of the strata, from an islet in the harbour called Cross Island* by Seoree Fort, and Antop hill to the eastward base of Pulshachee (Doongree) Hill.

The dip to the west is not always equally marked or equally high, nor is a dip always evident, particularly among the traps, while the fresh-water beds, or shale series, are in some places horizontal, or bent into open curves; but the facts with regard to the inclination of the beds are so frequently observable that, taken together with the form of the ground and arrangement of the rocks, quite sufficient evidence is seen to lead to the conclusion that Bombay Island like any other part of the neighbouring country is formed of a series of regularly stratified trap rocks; its greatest local peculiarity being, that interstratified with the traps various bands and layers of shaly rocks which have been deposited in water occur here.

General section.

Taking this view of the structure of the Island, and bearing in mind the main fact that all the inclinations of the trappean strata, together with most of those in the associated shales, have a common westerly dip,† it

* Communicated by Dr. Leith, who also informs me that this rock may be found in Salsette, continuing in the same line somewhere near the Vehar Lake. It is also referred to by Dr. Carter in notes "on the geology of the Islands around Bombay," (Journal, Bombay Branch Royal Asiatic Society, Vol. VI, page 178).

† A similar westerly inclination of the beds may be traced in the neighbouring trappean island of Elephanta, more prominently still in Trombay, and is also found in Salsette.

follows that the whole island presents an ascending series of stratified deposits commencing with the black basaltic rock of Seoree on the east, succeeded by the traps and shales of the eastern hills, which are overlaid again by the shaly beds seen at both sides of the flats, and terminated by the basaltic beds of Malabar ridge and Wurlee; as shown in the Sections, Plate II. It will be seen from these Sections that the natural arrangement of the rocks closely coincides with that given by Mr. G Clark (ante. p. 2). Other representations of the facts might possibly be given, but, as it appears, not consistently with the interpretation of the case suggested by even slight acquaintance with the ground; and this interpretation is not the less likely to be correct on account of its simplicity.

The key to the arrangement of the rocks is their stratification, and any difficulty which may have prevented the adoption of Mr. Clark's opinion probably arose from overlooking the fact that the stratification is found to prevail in both the aqueous and igneous rocks. It is well known that trappean rocks are frequently stratified or inter-

Rocks stratified.

stratified with chemically or simple mechanically formed aqueous rocks; but then the former are generally, more or less, easily discoverable to be finely granular or flaky, or else are found to have some of the internal or external characteristics of deposited or precipitated rocks, the particles of which have been arranged either by gravitation or the action of currents, or both. Otherwise they may resemble tabular basalt horizontally, but irregularly, spread out in sheets, or they may occur closely associated with other igneous rocks, the volcanic origin of which is more

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Mr. G. Clark states that it is general along the adjacent portion of the western coast of India, while it has been observed by ourselves to continue for 50 miles to the northward, and also to extend for several miles inland.

evident; or there may be circumstances connected with their position and ingredients from which their subaërial origin may be inferred.

The trappean rocks on Bombay Island form the mass; the occurrence of interstratified, decidedly aqueous, beds being exceptional in the larger trappean area of which these form only a small detached part. In their very regular and continuously parallel stratification they, like the rest of the great trappean formation of Western India, bear a striking resemblance to chemically formed aqueous rocks, while they all have an igneous composition, admitting of numerous mineralogical variations, as well as those of structure, texture, and color. Although they might all be termed at a first wide view basaltic, most of them would be called by English observers greenstone, but many of them seem to have a complex internal structure, some resembling varieties of felstone, or an intermediate combination of the minerals which go to form each of these rocks, while many of the more earthy amygdaloidal kinds might be called compact volcanic ash. Although some of the beds change in appearance along their extension, there is much more variety observed in passing across the strike from one bed to another, and yet this variation is not sufficiently limited to any horizon to deprive the whole series of its unity of character.

General aspect of Traps.

Taken together the rocks of the island present a great number of varieties, among which may be found the common gray and bluish sub-granular, sub-crystalline, and semi-compact intermediate trap which has been called trappite by Dr. Carter; the siliceous looking basaltic trap of Malabar Hill range, hard enough to mark glass; the black basaltic trap of Seoree which does the same; vesicular amygdaloidal trap containing geodes filled with quartz and zeolites; the soft soapy variegated ash of the eastern side of the Island; the red volcanic breccia of Sion; the

Varieties.

white trap of Dharavee; various kinds of ferruginous and flaky ash, and the intertrappean shales, sandstones, and flags, derived apparently from mechanical disintegration of the trappean rocks.*

* Whether the Bombay trap rocks were subaërial or deposited in water is an interesting question, which we are not quite able to decide from mere inspection of the ground.

The regularity and widely extended parallelism of their stratification and the flaky character of some of the ashy beds, together with the prevalence of amygdaloids and a certain internal lenticular structure frequently found in aqueous rocks, might be taken as affording some evidence that they were deposited beneath the sea. In several of them hand specimens could be found very nearly resembling the subaqueous trap rocks of Limerick in Ireland, and bands of ferruginous ash occur in places with as well defined a demarcation from the adjacent beds as could be found in many aqueous rocks. There is, on the whole, but little evidence of the alteration of one bed by the heat of another, not more perhaps than might have occurred under water, while the presence of what we are led to believe are conformable aqueous shales, occurring in the same manner as some of the more ashy beds, might be supposed to favor this view. On the other hand, most of the internal evidences which aqueous rocks afford concerning their origin are wanting, lamination is very rare, current marking, so far as we know, has never been observed, and the slight evidence which the shales might be supposed to afford is questionable, for it would not follow that because they are subaqueous the traps should be so also. The fossils which they contain are fresh-water forms, and if these are supposed to have been washed down into an estuary, the absence of marine forms remains to be accounted for before we can suppose the shales to have had other than a fresh-water origin. Arguing from analogy, any lake sufficiently extensive to have received the whole of the traps of Western India would require a peculiar geographical disposition of the land, with large river systems, in order to keep its water fresh, but of this no geological record is known to exist, nor can we venture to speculate upon the distribution of land and water during the period at which the traps were deposited.

Both subaqueous and subaërial varieties might exist together if the traps had been ejected in shallow water, above which they might in time be raised or raise themselves, when one variety of possibly subaqueous bedded trap might have been overflowed by a more basaltic kind, as would seem to have occurred in Bombay Island. The breccia of Sion points to the existence of a volcanic vent at no very great distance from where it is found, but we have not as yet any evidence regarding its precise locality, or as to its original condition whether subaërial, subaqueous only, or submarine.

Foci of eruption.

The *foci* of eruption of the traps of Western India and their precise method of deposition in such wide spread sheets, flows, or beds are as yet unknown, (unless the slender possibility of their having come up through the comparatively few dyke-fissures which they contain may be supposed to do away with the necessity for larger volcanic vents,) but these are questions which, although connected with the geological structure of Bombay Island, belong in a greater degree to other districts, where the rocks are much more largely developed and exposed.

3.—Rocks of the Island.

7. Alluvium; sand, and recent conglomerate.

Tertiary, probably Eocene ... {
6. Basaltic trap dykes.
5. Fossiliferous fresh-water beds, or shale series.
4. Amygdaloidal trap passing into solid gray trap and containing a band of breccia, and perhaps also the white trap of Dharavee.
3. Gray trap associated with fresh-water beds, shales, and flags.
2. Trappean breccia of Sion Hill, &c.
1. Black basaltic rock of Seoree, &c.
}

1.—*Black basaltic rock of Seoree, &c.*—This black rock is very peculiar; it has been described as "a Lydian stone, a black jasper or "chert, the result most probably of the action of the volcanic rocks "around on a stratified clay bed, the strata being still traceable, with "the same specific gravity as jasper, striking fire with steel, and being "luminous when rubbed in the dark, scratching glass and giving out "a strong sulphurous smell;" it is stated to dip at an angle of about 25°, and to split into semi-prismatical masses.—*(Dr. Buist).*

It is also said to "assume the appearance and structure of a coarse "black homogeneous jasper, and to contain fragments of trappite and "amygdaloidal rock."—*(Dr. Carter).*

We should feel inclined, from its aspect merely, to call this rock black compact (contemporaneous) melaphyre. It has a hardness slightly below 7·, and is very splintery, with much the character described by

Dr. Buist. The atmosphere does not affect it deeply; it is highly compact, has a semi-lustrous glistening conchoidal fracture, contains a few nodules of coarser trap rock, and here and there a scattered glassy-felspar crystal may be detected in its fracture. It is traversed by lines resembling lamination, in some places breaks into slab-like pieces, and in others has much the appearance of pitchstone. Before the blow pipe it fuses with but little greater difficulty, if any, than either the gray or basaltic trap of the island, and its analysis gives the following results:—*

Silica	61·60
Alumina	27·12
Sesquioxide of Iron...	2·12
Protoxide of Iron	4·60
Oxide of Manganese ...	trace.
Lime	2·10
Alkali	trace.
Loss—Water and organic matter ...	2·46
	100·00

* In composition it does not seem to resemble closely either felstone, greenstone, or basalt, the quantity of alumina it contains being much in excess of the proportions usually found in felstones, according to the analyses quoted by Jukes, (Manual of Geology, 1862, Chap. IV, p. 61, &c.,) while its silica is below the average amount.

Compared with analyses of greenstones given by the same authority, the quantities of these two largest constituents of the Seoree rock are both in excess, the closest resemblances, excluding fractional quantities, being to melaphyre, (above the mean of which its excess of silica is 9·, and that of alumina 6·;) or else to diorite, in which case these quantities are also larger, thus—

	Melaphyre. (Mean of Analyses by Durocher.)	Difference.	Seoree Rock. Analysis.	Diorite. (Mean of Analyses, Durocher.)	Difference.
Silica	52	+ 9	61	53	+ 8
Alumina	21	+ 6	27	16	+ 11
Potash	1		trace.	1	
Soda	4			2	
Lime	6	— 4	2	6	— 4
Magnesia	4			6	
Oxides of Iron and Manganese	9	— 3	6	14	— 8
Loss by ignition ..	1		2	1	

2. *Trappean breccia.*—This rock is met with in several places: its structure changes greatly, and it is often greatly decomposed; in some places it seems to pass into, or to be replaced by, a soft ashy

The mean analysis of basalt as quoted by Jukes, differs also from that of the Seoree rock, the same two chemical constituents being more abundant in the latter by 13 and 14 per cent. respectively.

Comparing it in the same way with dolerite, as tabulated in the same work, we have the following:—

	BASALT.	Difference.	SEOREE ROCK.	DOLERITE.	Difference.
Silica	48	+ 13	61	51	+ 10
Alumina	13	+ 14	27	14	+ 13
Potash	1		trace.		
Soda	3			3	
Lime	10	— 8	2	10	— 8
Magnesia	6		0	5	
Oxides of Iron and Manganese ...	13	— 7	0	14	— 8
Loss by ignition	3	— 1	2	1	

Its analysis, exclusive of the alkalies the absence of which, however, is an important difference in all these cases, very nearly approaches the maximum one of those given by Jukes of the trachytic lava called clinkstone, which is subjoined for the sake of comparison:—

	Maximum.	Minimum.	Mean.	Difference from mean.	SEOREE ROCK.
Silica	62·	54·	57·7	+ 3·8	61·60
Alumina	24·	17·	20·6	+ 7·6	27·12
Potash	9·	3·	6·	— 6·	} trace.
Soda	14·	3·	7·	— 7·	
Lime	3·5	0·	1·5	+ 0·5	2·10
Magnesia	2·	0·	0·5	— 0·5	·0
Oxides of Iron and Manganese ...	4·5	1·5	3·5	+ 3·12	6·18
Loss by ignition ..	3·5	1·0	3·2	— ·73	2·46 and a trace of Oxide of Manganese.

But clinkstone is even more similar in composition to the basaltic trap of Malabar Hill as will be seen upon comparing its analysis with that of the latter rock, given further on, page 24.

decomposed looking rock, and owing to the circumstance that it thins and thickens rapidly, its position in the series (if it has only one) is very difficult to determine. Its colour changes from red to white, green, blue, or brown, but its mixed, mottled, and heterogeneous, appearance distinguishes it from other varieties of the traps with which it is closely associated. It is by far the most volcanic looking rock in the Island; we were unable to discover any clear evidence that it forms the upper surface of an intrusive mass occupying a huge fissure in the other rocks; planes of stratification in it are generally absent, but its longitudinal arrangement parallel to the strike of the other beds of the Island shows the probability of its occurring as a large lenticular and contemporaneous mass.*

* At page 200 of 'Papers on the Geology of Western India,' Dr. Buist says of the breccia near the Flagstaff Hill east of Parel Tank, that 'where it is uniform in texture, it is cut up for water-troughs and aqueducts, being soft when first exposed to the air, and harden ing afterwards without abrasion or decay, in this respect resembling laterite.' He calls it trap-tuff, and quotes from a paper by Dr. Carter, in which it is stated closely to resemble the *Rothliegendes* of the *new red sandstone* series called also Exeter conglomerate, while its argillaceous, mottled, and ferruginous character ally it to the laterite. It is unnecessary to say more than that these resemblances are not general, if they do exist; it is very different from any portion of the *new red sandstone* which we have seen, and it has a much less ferruginous aspect than any laterite which has come under our observation. Neither does it afford any kind of proof that laterite is only a variety of intrusive igneous rock as Dr. Carter seems to have inferred.

The latter author mentions, at page 150 of the same volume, a granitic looking fragment of white diorite, which with fragments of coarse trap was found by Dr. Leith imbedded in black semi-jaspideous rock between Wadalla and Antop Hill. In another paper (Trans. Bombay Asiatic Society, No. XXI, Vol. VI, page 178), the author connects this circumstance with the occurrence of a piece of pegmatite in a basaltic dyke on the Island of Carinja, one of the Bombay group. Supposing the black semi-jaspideous rock to form *part of a dyke*, the occurrence may be explained on the hypothesis that the fragments were brought up with the intruding rock, but the evidence connected with the trappean breccia of this district was not found sufficient to enable us to say at what place it issued from greater depths on its way to the position which it now occupies.

3. *Gray trap associated with 'fresh-water beds,' shales, &c.*

4. *Amygdaloidal trap passing into solid gray trap, containing a band of breccia, and perhaps the white trap of Dharavee.*

As these two divisions of our list are closely connected and taken together form all the hills and rocks on the east side of the Island except those of Sion, Antop Hill, Seoree, and some places about Mazagaon, we include them for the sake of convenience in one description.*

The mass is principally gray or blue trap, with a composition and appearance resembling some greenstone, with the peculiarity, however, that it is stratified almost exactly like an aqueous rock. Such varieties of rock, if found in Great Britain *without* planes of stratification, would be called greenstone, and if they happened to be bedded, they would be called compact or amygdaloidal ash, as the case might be. The more compact varieties become in many places amygdaloid, and large tracts, particularly about Parel, are almost entirely occupied by the latter rock.

Upon the high ground of Raee Hill is a lenticular trappean band of a peculiarly brecciated and vesicular character, dying out both to the north and south, and evidently interposed between the strata of the

* The gray trap of the eastern hills, part of that called by Dr. Carter trappite, is said by him to be chiefly composed of crystalline felspar and hornblende, together with a little argillaceous earth. In the larger-grained specimens he says "we shall find tabular crystals of white felspar, *amorphous crystals*† of green hornblende, a small quantity of greenish or bluish argillaceous earth, and more or less green earth, olivine, and small particles of *peroxide of iron*, probably titaniferous iron or *rutile*, from its rich brown red colour in some parts, *most of which are caught up by the magnetized needle*† in their natural state when the rock is pulverised; cavities are sparsely scattered in it, which contain varieties of scolezite or needle stone." The rock seems to fall within the class called intermediate traps by Professor Jukes, its principal ingredients being felspar and hornblende or augite, but possessing many complex varieties in its composition, some of the beds being more siliceous than others, and yet seldom or never taking the ordinary appearance of felstones, or being acted upon to the same extent by the atmosphere as they are.

(† These italics are our own. Particles caught up by the magnet are more probably magnetite, (magnetic iron,) the other minerals mentioned being very faintly, if at all, attracted by the magnet.)

gray trap; it is included in the volcanic breccia by Drs. Carter and Buist, but seems to be a separate band of very similar rock.*

Other brecciated trappean rocks occur along the shore near Mazagaon. In one of these Dr. Leith informs me he found what appeared doubtfully to be fossil bones, but was unable to make out any traces of bony structure.

A coarse white variety of trap, in appearance much resembling a sandstone, occurs at the northern end of the Island about the village of Dharavee.

Associated with these gray trap rocks, and affording good evidence of their being stratified, are several narrow bands of 'sedimentary' shaly rock; they contain some fossils (obscure plants and Cyprides), and consist of brownish or gray shales, always having a dip to the west, though some times at a very small angle. They seem to occur irregularly on different horizons, and Dr. Buist mentions that in one place they have been cut up by the intrusion of a trap dyke.

5. *Fossiliferous 'fresh-water beds,' shales, and flags.*—The rocks last mentioned as associated with the gray traps are among the lowest of this series, though the general description of them has been reserved for the largest group. This seems to occupy much of the ground below the surface of the flats, where trappean rocks are doubtless interstratified with these sedimentary beds. They run all along the eastern base of Malabar ridge, and are well exposed there in several places, to be hereafter pointed out. In the flats again and at their eastern side they also appear, having generally a light brown colour and fine texture, altogether very similar to those lower bands which occur among the traps of the east of the island, but at the sluices their colour was observed to be a dark-green passing into black. Bands of a white colour and siliceous are associated with them,† and they all

* This is the rock alluded to by Dr. Buist, as becoming hard under exposure to the weather.

† Dr. Carter.

seem to have been formed from the fine detritus of volcanic matter. Flaggy beds occur among these shales; thin slabs of considerable size, and bearing the impressions of large vegetable stems, having been recently raised during the operations connected with building the gas works on the Parel Road at the eastern side of the flats (1863).

This shale series has been proved almost everywhere to be highly fossiliferous, but we had neither the good fortune nor the opportunity to discover more than a few specimens of *Rana pusilla* at the sluices, and to observe that the shales there, as well as in nearly every place where we saw them, contained quantities of vegetable impressions and numbers of little *Cyprides.**

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* An extended notice (with illustrations of fossils in the Volume of Plates) concerning the organic remains found in these rocks by Dr. Leith, their first discoverer, and by Dr. Carter is given by the latter in his paper already quoted; (Journal Bombay Branch Royal Asiatic Society, Vol. V, page 161,) and see Geological Papers on Western India, pp. 131, &c.

The following is a list of the fossils found:—

ANIMALS.

VERTEBRATA. Reptilia.

Testudo Leithii. Carter.

Amphibia.

Rana pusilla. Owen.

Rana sp. larger than *R. pusilla* (only footprints found).

ARTICULATA. Insecta.

Elytra of beetles.

Crustacea (Entomostraca).

Cypris cylindrica.—Sow.

C, semi-marginata.—Carter.

C. sp.

MOLLUSCA.

Gasteropoda.

Melania?

Pupa??

6. *Dykes.*—These will be mentioned amongst the details given below; they are not greatly different from the ordinary trap, but somewhat more compact or concretionary, or of slightly different texture from that of the bedded rocks; they penetrate, and they sometimes yield more rapidly to the action of the atmosphere than, the traps in their vicinity.

Dyke-like masses occur in the volcanic breccia of Sion, but from their similarity to the neighbouring rock, it is all but impossible to say that they do not owe this appearance to the occurrence of parallel master-joints.

Basaltic trap of Malabar Hill.—This is an extremely hard dark variety of bedded trap; it marks glass, yields but little, and in a peculiar manner, to the atmospheric action; in some places the only effect produced being a slight superficial oxidation of its combined iron, in others it is traversed by strong joints, between which large spaces have been formed, and most of the remaining angles, owing to a rudely developed concretionary structure, have been partially rounded off.

Although many of its surfaces, both horizontal and vertical, exhibit a more or less hexagonal network of divisions, filled with either white quartz or zeolite veins, thus indicating a concealed prismatic structure, it is rarely, and then but rudely, columnar. The thickness of the mass is uncertain, as it may have extended further in a vertical direction; in places, however, it exceeds 80 feet.* The composition of an average

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PLANTS.

Leaves, stems, and seeds, all more or less indistinct, and wood, chiefly dicotyledonous. The "cormiform" and "globose" roots described and figured by Dr. Carter, and of which the original specimens are preserved in the Museum of the Bombay Branch Royal Asiatic Society, have very much the appearance of concretions, and their organic origin must be considered extremely doubtful.

* This rock is very finely columnar in its extension to the north beyond Bombay Island. See Dr. Carter's Contributions to the Geology of Western India, (Journal, Bombay Branch Royal Asiatic Society, Vol. VI. pp. 174-6.

specimen is subjoined, from analysis made at the Geological Survey Office, Calcutta, by Mr. A. Tween :—

Malabar Hill basaltic trap.

Silica	59·80
Alumina	22·75
Sesquioxide of iron	4·92
Protoxide of iron	5·88
Lime	1·80
Alkali	2·50
Water and organic matter ...	2·36
	100·00

7. *Alluvium; sand, clay, recent conglomerate, &c.*—As the names of these almost include their description, they do not require further notice in this place.

4. Relations between the form of the ground and its geological structure.

A palpable connexion exists here between the form of the ground and its structure. The elongated shape of the island is plainly due to the direction of the beds or flows of trap rock of which it is chiefly formed, and the reason that these have assumed in most instances a ridge-like appearance is because they have been tilted so as to make (somewhat of) an angle with the horizon, thus exposing beds of different texture and capable of different resistance to the powerful action of erosion under which they received their present forms, the result being that certain harder bands withstood this action more than others, and thus determined the direction of the lines of more lofty ground.

Rocks tilted.

Another circumstance to which the varieties in the form of the ground may no doubt be largely attributed is the occurrence of the fresh-water beds among the harder trap rocks, presenting an even greater difference of texture as regards the whole group than exists among the trap rocks themselves. Upon these soft fresh-water beds denudation would produce the greatest results, and probably where they lie most nearly horizontal the widest flats, terminating at the steepest features, might be found; thus we see that where openings have been made in the flats sufficiently large to expose the stratification of the rocks beneath, they are found to dip, but slightly, to the west, or undulate about a nearly horizontal plane, and where the flats are bounded by the Malabar Hill range—its massive flows of hard basalt overlying the softer shales with a well defined dip to the west—there the characteristic form of ridge with its short steep eastern face and longer slope to the west is most clearly developed.

Beds of unequal hardness.

Beyond the limits of Bombay Island other facts exist tending to show that denudation, together with the stratification of the traps, is the principal cause to which the features of the ground in the vicinity may be attributed.

The flat plain of the Deccan to the east coinciding with the horizontal stratification of its rocks, and the steep vertical cliffs of the Ghâts or Syhadree mountains along its western edge, are illustrations upon a grand scale of the features usual under such stratigraphical conditions as obviously resulted in their production. Westwards, however, in the neighbourhood of Bombay, the strata are found to incline seawards, and the erosion acting along their strike has in most instances given rise to features coinciding therewith. The coincidence of much of the coast line itself with the general strike, and the absence of long head-lands projecting to the west, may be adduced as large examples of the relation between geological structure and physical form, while the prolongation of the Malabar Hill range to the northwards* and into promontories at Wurlee and Malabar Points in the Island of Bombay may be taken as smaller features due to the same cause.

Denudation.

As has been already mentioned, the occurrence of these fresh-water beds has probably caused much of the diversity of form which the Island presents, and although the geology of the Deccan and of Western India is hardly well enough known to enable us to speak with certainty of the smaller details, it may be said that these fresh-water beds are an exceptional feature in the trappean districts of Western India. Analogues probably exist, such as the fresh-water limestones, which are in some distant localities interposed between the traps, but over many large trappean areas, which have been traversed by us, all these fresh-water deposits seem to be entirely absent. No good grounds have been assigned for a supposition which has been advanced† that the strongly marked

Fresh-water beds exceptional:

* Dr. Buist states that the basaltic ridge 'stretches to Bassein' about 27 miles to the northwards, where fine basaltic columns may be seen.

† Geological Papers on Western India, page 189.

flows or beds so well exposed in the steep precipices of the Ghâts are each separated by some of these softer beds, and their absence being the rule, it is somewhat singular to find them alternate so frequently with the traps within the Island of Bombay, for, although they may be merely local, their accumulation at different positions in the section marks the occurrence of intervals of rest during which the direct accumulation of igneous or trappean materials ceased, in their vicinity at all events, and if such breaks took place there they probably occurred from time to time elsewhere as well. The irruption of trappean materials having been discontinued sufficiently long for vegetation to cover the ground, tropical rains would perhaps fully account for most of the results immediately following, and indeed the existence of floods is suggested by the pieces of drift wood mentioned by Dr. Carter in the papers quoted (page 133). Whilst we compare the general absence of these fresh-water beds in the trap rocks with their local abundance at Bombay, it must be recollected that, although the Island presents a section the depth of which is estimated at 1,200 or 1,500 feet, there is a possibility that its rocks belong to a higher place in the series than those of the main-land, and may therefore be quite unrepresented along the Ghâts, where lower beds would consequently occur. As indications of this possibility may be mentioned the slight but general dip to the west which has been observed for very considerable distances to the north and south of Bombay, leading to the inference that an axis of curvature runs along parallel to the north and south range of the Ghâts, and between them and the sea. Some of the furthest beds visible on the west of this axis would be those of Bombay Island, and even if the low dip of 10° to the west be assigned to them and a large allowance made for curvature as well, it will be seen that, if their present outcrops were produced over the intervening country to the

abundant in Bombay.

Rocks of Bombay high in series.

east, they would pass far above the highest pinnacles of the Ghâts, which are situated from 30 to 50 miles inland.*

It should also be remembered that these fresh-water beds have been traced but a short way, comparatively speaking, beyond Bombay Island, while many of them appear to thin out both to the north and south within its limits, and if their occurrence, or the cause which produced them, was merely local, we have no warrant for supposing that they extended further in one direction than another. The most natural supposition regarding their occurrence seems to be this, that the trappean flows (considering these to be subaërial) assumed here a more lenticular form than is elsewhere apparent, and that flows approaching from opposite sides left shallow basins, which became the repositories of mud and sand, the results of disintegration of the trap washed down by rain during long intervals of cessation between the eruptions of the trappean materials; intervals in which the muddy basins became the receptacles of many forms of organic existence: and then subsequent trappean flows overran and covered up these lacustrine deposits, long afterwards to be exposed again by denudation, nearly as we see them now.

Possible cause of appearances.

* The westerly dip of the traps may be traced for several miles to the east of Bombay, and is particularly conspicuous in the harbour upon the Islands of Trombay, Elephanta, and Carinja. At Matheran, however, and in its neighbourhood, the beds of trap are as horizontal as at the Ghâts.

5. Denudation.

The denudation, or wearing away, of the rocks has had so much to do with the form of the ground that it deserves some notice.

All recent geological inquiries in this direction tend to show that large as were the results previously attributed to this action, this estimate fell far short of the reality; that to its powerful agency, more particularly the portion of it due to atmospheric causes, are to be ascribed almost all the grand and varied features of the ground in those countries where volcanoes do not exist, or have not recently been active. Bombay Island presents no exception to this observation, for although here and on the neighbouring main-land the rocks are almost entirely igneous, it is chiefly from general elevation, during the process of denudation or the combinations resulting from the disintegration of the land either when moving or in a state of rest, and not from any direct local exertion of volcanic agency, that the ground has received its present features.

Cliffs of the Ghâts.

The grand precipices of the Ghâts, which give such interest to the distant portions of the landscapes about Bombay, present the finest examples of seaworn cliffs formed probably during a long period of gradual elevation; while in the extremes of tropical heat and wet, powerful sun and swollen torrents, each acting for months together on the easily abraded trappean rocks, we have instances of atmospheric action likely to produce enormous effects. When it is considered, too, that an unknown thickness of rock has been worn away from above the very highest of the Ghâts' mountains, themselves more than 4,000 feet above the sea, and that their steep western precipices, with heights of 2,000 feet, are situated so many miles inland; while portions of the same group of rocks in their extension now form the coast line, and further, that nearly this thickness of 2,000 feet of solid rock has been, in all probability, excavated and removed from off the intervening country, some idea may be gained of the vast extent of this action of denudation.

To this cause the occurrence of all the islands along the coast is due. Its effects upon Bombay Island itself are evident, in the fine crags overlooking the western side of Back bay,* the breach in Malabar ridge at the Vallade, the irregular outline of the Island, the wide space occupied by the flats, and the picturesque forms of the hills on its eastern side, with deep inlets and shallow bays, now almost filled with detritus, washed down by the rivers of the main land. The peaked outlines of the hills at the north of the Island are derived from the gradual degradation of the tough breccia of which they are composed, and not from any force of protrusion of their material, and their similarity to each other and their conical shape are due to the almost total absence of clearly defined stratification and to the general sameness in the structure of their rocks, while stratification alone has influenced the form assumed under denudation by the rest of the hills within the Island. The texture of the trap rocks presents so little difference in places that the denudation has not very variously affected them, but the solid ridge of Malabar Hill on one hand shows how it has been resisted, while the inlets on the east and the abrupt slopes overlooking the harbour exhibit its results upon much softer beds. The flats, again, present an example of this action upon soft beds: the low ground about the Fort and Colaba are places where its effects have been unusually great, but here the angles of dip are extremely low, and one of the hardest but most splintery rocks in the Island, that of Antop Hill, appearing at intervals with wide gaps between, is an instance of the way in which such rocks yield to this force.

Vast extent of denudation.

* These cliffs, owing to the rapid rate at which building has lately proceeded in Bombay, have been so extensively quarried that they now present an artificial appearance, which, however, cannot conceal many of the prominent features, such as the great natural clefts or vertical separations of the rock. The lines of flow or stratification are also visible in many places, although the general tendency of fresh fractures on a large scale is to conceal such lines in these hard rocks.

The gap in Malabar ridge at the Vallade was probably produced by some such circumstance as undulation or approach to horizontality connected with the soft fresh-water beds which underlie the basalt; and nearly every point in the Island presents some instance of the effect of denudation modified by local circumstances.

Both marine and subaërial.

It is difficult to distinguish those features in the Island, which may be due to marine or to subaërial denudation; probably all have been originally caused by the former, but subsequently reduced by the wasting agency of the latter. Both varieties of the action are in operation still and the latter at least is proved to have been in existence at a very remote period by the occurrence of the fresh-water beds, which were doubtless produced by natural causes operating very much as they do at the present time.

6. Elevation and depression.

Closely connected with the denudation are the actions of elevation and depression, which have exposed different portions of the ground to its influence.

Long continued.

It is at least possible, if not most likely, that such cliffs as the Ghâts present were formed either while the ground gradually emerged from the sea or sank beneath it. In either case an immense period of time must have elapsed during the operation of cutting these cliffs, and supposing neither great elevation nor depression to have taken place, a period as indefinitely long perhaps would be required to eat back from the present coast line to 40 miles inland through a height of some 2,000 feet of rocks to reach the place where the Ghâts' mountains now rise from the low Konkan. But assuming that the land was worn away during its elevation, then, even before the Ghâts' cliffs themselves were formed, denudation had been going on, reducing the once higher country to a lower level; as is marked by the many flat topped mountains rising above the

general height of the range, and as the summits of these hills suffered erosion also, there is nothing to show how much higher they may have reached, or when an action, already proved to have been so extensive, may have begun to operate.

The very magnitude of this vast action of denudation which has left mountains two and three thousand feet higher than the plateau of the Deccan,—itself two thousand feet above the sea,—inclines us to attribute it to the strong agency of marine erosion rather than to that of atmospheric origin. Cliffs are to be found on the sides of these lofty mountains quite of the same character as those of the Ghâts below, and if these were formed by the sea, as is almost beyond a doubt, then this portion of the Deccan must have experienced an elevation of many hundred feet above sea-level.

As the excavation of the cliffs and glens could only have proceeded at a slow rate, the time occupied by the elevation* so as to bring all parts of the country within reach of the sea's surface, at which alone such active destruction of the rocks goes on, must have been a period of great length; but it is perhaps as impossible to say when it ended as when it commenced, and, if the elevation were so slow as to be almost imperceptible, it might even continue at the present time.

Recent.

Whatever movements of the ground affected the country to which we have just alluded no doubt extended also to Bombay Island, but here we have further evidence of very recent actions both of upheaval and depression. The blue clay of the flats containing Mangrove roots is said† to have been found near Sion, and in other parts of the Island, undisturbed at places now beyond the reach of the sea. Above this, and at an elevation of 10 feet higher than sea-level, are sea-shells, gravel, and sand, loose or cemented

* Assuming that it was during a time when the land was being raised that the cliffs were formed.

† Dr. Buist, 'Papers on the Geology of Western India', pp. 181-4.

into a variety of open shell-limestone 3 to 10 feet thick. From this it follows that the clay containing the roots of Mangroves, which only grow within the tide marks, must have been depressed in order to allow the stratified deposit of sea shells and gravel to have accumulated, and afterwards both must have been elevated as high at least as the position in which they are now found.*

When the shell-concrete or recent conglomerate was deposited so widely as it is found to have been all over the flats this Bombay district must have consisted of a group of several Islands, a fact which has not been overlooked by previous observers. Mahim at its northern end is mentioned in an old manuscript as forming a distinct Island,† and Dr. Fryer, who visited Bombay in 1674-75, alludes to the same fact.‡

That much of the low ground in the Island is not now submerged during the prevalence of westerly gales in the monsoon, while partly due to elevation of the land, is also largely the result of artificial embankments and floodgates at the Vallade, at the sluices near Wurlee Hill, and on the road from thence to Mahim wood, as well perhaps as to the natural barriers in the form of beaches, which the sea has thrown up at both the north and south ends of the Island.

* The places where these deposits occur are not particularly pointed out; they are said to be visible all round the Island, and are treated of at considerable length by the above author. Where we have seen them their position is that which is described, and the fact of an elevation seems to be established; but knowing that portions of the Island are at a lower level than high water mark, some uncertainty as to the amount of these changes of level has been felt. This, if it existed, was doubtless removed by the extensive opportunities which Dr. Buist had of observing these deposits. At somewhat distant places, however, along the coast of the North Konkan, clear evidence of an elevation of the land was seen in the existence of similar littoral deposits considerably above high water mark, and this is strongly corroborative of the facts observed in Bombay Island.

† Dr. Buist, Geological Papers on Western India, 175.

‡ New account of East India and Persia, in eight letters, being nine years' travels, begun 1672 and finished 1681, by J. Fryer, M. D., *London*, 1698, fol. p. 47.

A considerable quantity of blown sand occurs near Mahim, where the low scarp which the sand presents to the west exposes a section through an old graveyard now completely buried beneath the sand.

7. Water.

Although the Island does not contain any thing more like a river than a few sluggish creeks and drains, or intermittent streamlets, which flow only during the monsoon, still a plentiful supply of fresh-water is to be obtained from among the various strata of which it is composed.

As might be expected the greatest quantity is found in low situations. Where wells are sunk in the saline blue clay the water is brackish; in other situations it is more or less pure.

The basalt of Malabar Hill is said to afford but little water, more being found in the traps to the east; any of the traps, and particularly those containing many fissures or other lines of separation, will afford water just as it is obtained all over the Deccan or other trappean countries by sinking wells, which are filled by infiltration; the supply depending upon the quantity of fissures and the extent of surface upon which the water falls and from which the supply is derived.

None of the recent strata of the Island seem to be particularly porous, as they have the power of separating salt water from fresh, where wells are sunk through them along the coast to below the sea level, and to this source of supply is perhaps due the rising and falling of the water in certain wells depending upon and corresponding with the state of the tide,* but this is a question beyond our reach to consider further for want of more ample data.

* An interesting section upon this subject will be found in the paper by Dr. Buist before alluded to; he says the supply of water is sufficient for nearly half a million of people, although the annual evaporation equals the annual rain fall (on an average 70 inches); that wells sunk in the shell-concrete or recent conglomerate furnish good water, but when they reach the saline clays beneath it becomes brackish; that the (fresh-water beds) shale series

8. FAULTS.

The only well marked fault which has been observed is that at the north end of Antop Hill and between it and Muddly-Antop.

The difference of the rocks on each side is very great, and the change from one to the other sudden, but neither of these are sufficient reasons for supposing a fault to exist. This is one of those cases in which, although not perfectly clear, the existence of a fault is so strongly indicated by local circumstances that we feel warranted in accepting it as an explanation of the facts before us. As these circumstances will be mentioned in the details further on, reference to this subject will be found at that place.

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supply abundance of fresh-water, and that tidal fluctuations in the level of the water in those wells sunk in littoral concrete near the shore can be observed daily, but at the distance of a mile from the sea they are easily discernible at spring tides; that the quality of the water is not sensibly affected by any connection with the sea which may exist, and it is suggested that the change of level is caused by the ponding back of the usual discharge (? filtration) from the shore to the sea. Springs are mentioned further on, and in one case during the excavation of a tank in trap rock, half a mile from the sea and near the Baboola Tank, a great rush of water containing half as much salt as sea water is stated to have entered this near the bottom. From the heights given upon the large Map of Bombay Island published by Government this tank would seem to have been sunk considerably below sea level.

9. Details.

It being possible to follow more or less perfectly the natural order of the rocks, by commencing at the north-east corner of the Island, we shall take it first, proceeding with the description from thence southwards, and afterwards towards the west.

About Sion the ground is steep and hilly, the eminences more or less conical, rising somewhat abruptly from the muddy flats, salt pans, and shallow bays, which are left dry in that neighbourhood by every tide. These hills, although not high, are all picturesque, perhaps more so than any other parts of the Island; the principal ones are Sion Hill upon which Sion Fort is situated; another between the village of Sion and the Railway (in course of removal for purposes of reclamation near Bombay City); Pulshachee (Doongree) Hill south of Sion Fort, and still further southward Antop Hill. The heights of the latter are from 85 to 127 feet, but the remainder of the ground near this is low, flat, or undulating. These hills present an exception to all others in Bombay Island, for while the rest have more or less the character of ridges this character is not here prominent, and can only be traced obscurely in the *alignement* of Antop and Pulshachee Hills; in a low elevation which connects ground near the latter with Sion Hill; and in a persistent band of gray-trap, forming somewhat higher ground than occurs in its vicinity, which reaches (with regard to this locality) from the village of Wadalla to Riva Fort, broken through, however, and crossed by a portion of the flats south of the latter place.

Sion Hill, and vicinity.

The conical and highest hills are all formed of the red breccia, sometimes very lateritic in appearance, which has been called Tufa by Dr. Buist and forms part of Dr. Carter's "third effusion." We have Dr. Buist's and Dr. Carter's authority for its extending to, and occurring in great force on, the Island of Salsette to the northward, but southwards,

it would seem to die out as it is not seen, at least not with the same appearance, southward of Wadalla village. A somewhat close inspection of the ground leads to the discovery of obscure dips towards the westward in the breccia, and this is found to correspond with the inclination to the west observed in the gray trap and Dharavee beds. The extension of the breccia from north to south also corresponds with the run of the gray trap; and further, upon examining such situations as underlying rocks (if also corresponding to the obscure dip of the breccia) would be likely to appear in—namely, the eastern side of the exposure of the latter, and the deep hollows where the sea has cut across its strike—in these places a very different variety of rock is found, which, although locally varying, still so closely resembles the black-trap of Antop Hill that there is no reason to doubt its belonging to the same group. This black basaltic rock may be all but traced from near Antop Hill itself northwards along the shore of Muddly-Antop just skirting that mass of breccia on the east; and a shingly bank or bar which almost connects Muddly-Antop Hill with Pulshachee Hill is evidently formed from the breaking up of this black rock. Still further in this direction, just below the magazine on the south point of Pulshachee Hill, the black-trap itself is seen cropping to the surface on the shore, as if coming out from beneath the breccia. It could not be traced onwards in this direction possibly because its surface may have been uneven before it was overlaid by the red breccia, but it re-appears again with somewhat of the appearance of horizontal bedding on the road from Sion to Matoonga close to the village of Agurwara. Here it seems to have been exposed by denudation at a place where the surface formed of it was slightly higher perhaps than elsewhere in the neighbourhood. The quantity exposed is small, and it is only visible in one or two localities close to each other.

Antop Hill.

Not far from the patch just mentioned the Sion Road passes by a causeway or embankment over a portion of the salt marsh or bay

between Matoonga, Muddly-Antop, and the neighbourhood of Pulshachee Hill. Close to this road and embankment there are pieces of rock strangely twisted and apparently much altered, projecting from the mud of the flats and skirting the edges of the bay; these are, although somewhat different, so like the rest of the black 'basaltic' material of Antop Hill that we cannot help thinking them the same. Although these rocks have a somewhat flinty appearance they are in places brecciated, and as it were present a rough passage from the black-trap into the red breccia, such as might occur from alteration produced by the breccia having overflowed the black rock in a melted state; and this fact,—taken in connection with the circumstance that portions of the breccia left by erosion project from the mass while the black rock appears close by all round them, re-appears as an inlying exposure, and occupies a lower position,—seems to warrant the conclusion that the whole of the Sion breccia is an intercalated mass of more or less lenticular shape interposed between the black rock and the gray-trap of Matoonga and Riva Fort which we have placed next above it in our classification of the rocks.

Taking this view of the position of the black rock below the breccia it seems to occupy a very natural position,* until we find it rising

* Either as a contemporaneously deposited or horizontally injected sheet of igneous rock. It has been thought by some observers to resemble an altered argillaceous deposit; if this were so, the depth to which the alteration had affected it would be very great indeed. Lines as much resembling lamination as those which it contains may be frequently observed in compact felstone and basaltic traps. And although its composition may resemble that of an altered shale, its structure does not bear out this supposition. Among the numerous intertrappean sedimentary deposits nothing has been noticed at all resembling it, nor does the effect of the overlying trap in altering the texture of these deposits ever (so far as our observations go) extend more than a few inches, or, at the most, a foot or two. The Basalt of Malabar Hill, although admitted by all to have been once fluid, has produced scarcely any perceptible alteration in the frog-beds at the sluices. Lastly, this very basalt of Malabar Hill, as typical an igneous rock as it is possible to conceive, has a composition just as much resembling that of an altered shale, as the flinty jaspideous rock of Seoree.

into a bulky elevation of 85 feet at Antop Hill. The ridge here formed by Antop and Muddly-Antop Hills (upon the western slope of which the English burial ground is situated) appears to be crossed by a fault which has changed the level of the lower black trappean rock, allowing it to abut against the breccia of the northern and last named half of the ridge. There are other suppositions, such as previous erosion of the lower rock and much inequality in its surface, which might account for the appearances here, but the difference in level is so much greater than occurs elsewhere, and the line of junction seems to be so straight and clearly defined (bearing about east 15° north), that a fault appears the most probable supposition to explain the positions of these rocks. The detritus from the hill lies so thickly upon its western flank that the junction of the breccia (which appears to occupy the hollow near the village of Gowaree) with the rock of Antop Hill could not be seen, but upon the supposition of the fault the breccia here may very possibly resemble that on the east side of Pulshachee Hill below the magazine.

From the nature of the ground on the west slopes of Antop Hill the black splintery rock, although close to the surface, is not well exposed, but on the east it forms naked cliffs; upon closely inspecting these, lines like those of lamination or fine stratification may be observed extending as if horizontally; some little cavities in the rock, too, are elongated in this direction, and numerous slabs detached from the cliff by the weather and lying at its foot are of a tabular character such as might be assumed by a flaggy rock on breaking up. The whole rock of this hill is of a curious compact and almost flinty kind, and if it were originally a deposited or sedimentary rock, it is difficult to imagine how the whole mass could have been so completely altered as to become quite the same from top to bottom through a thickness of seventy-five to eighty feet merely by the contact and heat of probably thinner trappean flows applied either above or below, or both; and there is nothing in the structure of the ground to lead to the

conclusion that this Antop Hill rock, in its present form, was ever overflowed, and surrounded by trap-rock; only its denuded surface being now exposed.

It differs greatly in appearance from any of the trap-rocks commonly found in the neighbourhood, and, as far as we know, is only a local variety of this rock. It has none of the appearances characteristic of a dyke, no walls nor joint-fissures such as dykes frequently present, running in the same direction as their strike; and the material is quite unlike any of the dykes usually found in these trappean rocks. It re-appears at Seoree with the same general aspect and is said to occur again, forming the rock called Cross Island in the harbour at a distance of several miles, but still directly in the line of strike. Taking this long range parallel to the general stratification of the Island, and the appearance of the same rock underlying the breccia south of Sion, into consideration, it seems most natural to suppose that this black jaspideous rock is a mass or flow of lava-like trap cut through by a fault which alters its level close to the burial ground on Antop Hill. The fault may perhaps have allowed its dip to change so as to have exposed it differently to the denuding forces, and thus have caused it to assume the form of hills to the south, while northward it makes the floor or basement upon which other hills of a different material stand.

Just to the north of where the above-mentioned fault is supposed to run, and overlooking the burial ground on Antop Hill, a higher elevation exposes in one place a very peculiar appearance in the breccia. The rock, elsewhere red, is here white, ashy looking, and tufaceous, enclosing white fragments which appear like portions of the black compact rock in a highly altered state; it has a very volcanic appearance, and is traversed by numerous hard and ferruginous strings and veins, is peculiarly open to the action of the weather, and apparently wears down under its influence to a red clay.

This rock is stated by Dr. Carter to cut across the other trap in its neighbourhood, and Dr. Leith informs us that it encloses tilted portions of the shale rocks said to occur just below it; but although the ground hereabouts was repeatedly crossed in different directions, none of the shales except those previously mentioned were observed by us, nor was anything seen to prove that the variegated rock occurs as an intrusive dyke; on the contrary, whether intrusive or otherwise, its appearance forming a little cliff or scarp along the brow of one hill between different kinds of trap above and below, widening out where the crest of the ridge has been lowered to its level by erosion, thinning away at one end beneath the Flagstaff Hill (the shape of which more strongly perhaps than any thing else bespeaks its stratification), and appearing to do the same in the other direction, where it is only traceable by the blocks, &c.,—which may have been separated from its scarp or outcrop, and now lie on the hill side a little below the level where it would probably run on beneath the solid scarp of hard gray trap which forms the crest of Raee Hill,—all these circumstances unite in favour of its being a lenticular mass interposed between two of the beds or flows of the local trap.

Rocks near Parel.

The trap-rocks around Parel occupy a wider space than anywhere else in the Island; they are chiefly varieties of compact gray and amygdaloidal trap about Parel itself; the latter are more common, and they extend to the southward beyond Chinchpooglee towards the native town. The gray-trap is observable in greater force along the east side of this tract, but bands of it appear also immediately to the west of Parel: further west again the rock seems to be more amygdaloidal, and just at the edge of the flats some of the fresh-water beds appear at intervals in the low ground. They may be seen in the ditches along the Railway and at the south-east angle where the new road from Parel crosses it. Here they seem to be interstratified with alternating beds of amygdaloid and muddy looking ash.

On the east side of the Railway, about a mile to the south of this, some openings in connexion with the gas-works have been made just at the east edge of the flats, and these are found to contain gray and brown flaggy and shaly beds, with numerous large vegetable impressions between the layers; they would seem to undulate rather irregularly, in some places having a low westerly dip,* and close to them on the east numerous old quarries and tanks expose the amygdaloids associated with the gray-trap. Similar amygdaloid, ashy, and shaly beds may be seen in many spots between this and the Race-course, and would seem to extend, associated with gray-trap, past Byculla towards the native town. Other of the flaggy beds appear near the north-western and south-eastern corners of the Race-course, and there is good reason to believe that either these, or the rocks last mentioned, occur in many places, at no great distance from the surface, in the flats.

Mazagaon.

Between Mazagaon and the Race-course many openings in gray and amygdaloidal trap may be seen, but at Mazagaon itself, on the side of the hills overlooking the harbour, there is much soft decomposed ashy looking trap, of somewhat similar appearance to that beneath Rowla Hill. As it is variegated, pink and green, it also resembles the rock seen in the railway-cutting at Sion. Its relations to the adjacent rocks are not very evident, but as it is capped by a band of hard gray-trap, the probability is that like the other varieties of rock on the Island it also is interstratified.† Eastward of this and extending into the harbour

* Since this ground was inspected other openings have been made in the flats further west and on that side of the Bombay, Baroda, and Central India Railway; in these a coarse granular sandstone, which seemed to occur in very thick beds and the stratification of which was undiscernible, was found; it seems to be wholly made up of disintegrated trap, and doubtless is a part of the shaly series found close by. (A. B. W., November 1864).

† During some recent excavations at Belvidere and Mazagaon Hill the hard band of trap above was seen to curve considerably, descending the hill and again apparently re-assuming a horizontal appearance at its base—(From information supplied by Dr. Leith). The rapid removal of the hill by one of the Reclamation Companies has so much interfered with this place that the connexion of the hard stratum can no longer be traced.

are varieties of gray-trap and amygdaloid of very similar appearance to those seen elsewhere.

The narrow band of shales containing *Cyprides*, which occurs at Nowrojee Hill between two beds or flows of gray-trap, has been noticed by Drs. Carter and Buist, and also another (which from its position should be a higher band) appearing in Baboola Tank to the west.

The usual varieties of gray-trap extend from this locality to the Fort along the eastern side of the Island.

Colaba Islands.

The Islands of Colaba, united by causeways to the island of Bombay, are composed of varieties of dark and pale gray-trap, in some places resembling a crystalline greenstone. These trap-flows undulate, and are apparently nearly horizontal, but, taken collectively, seem to have a slight dip to the north of west. Large surfaces of these trap-rocks, sometimes containing small garnets and zeolites, are exposed between tide-marks on the Back Bay side of the promontory formed by connecting these two Islands. In a small unbuilt tank near the coal sheds, behind the Officers' quarters on the east side of the promontory, a thin band of nearly horizontal, shaly, and flaggy, beds was found appearing to incline slightly to the north of west; these do not exceed five feet in thickness; they much resemble the rest of the fresh-water beds, and they contain numerous small fragmentary impressions of plants, among which one bearing an obscure resemblance to a leaf was found.*

Columnar trap.

A group of basaltic columns is marked upon Dr. Carter's map off the shore of the Esplanade in Back Bay. These were not reachable on account of the tide, and although the traps of the Island are not generally columnar, other portions of the traps of Western India are too frequently so to render such an occurrence extraordinary.

* Information kindly given by Dr. Leith led to the finding of this place.

A small exposure of trap, we are informed by Dr. Leith, exists on Grant Road near the place where chunam kilns are marked upon the map.

As the flats are almost entirely occupied by recent and superficial deposits they will be mentioned subsequently, and we will now pass on to the Malabar ridge. The basaltic flows, which from end to end occupy the upper parts and western slopes of this ridge, are everywhere almost exactly similar, presenting far less variety in their composition than any of the other trappean rocks of the Island. The basalt is massive, compact, and blackish, very strong, hard and tough, with but a thin rusty coating on its most weathered surfaces. Dr. Carter marks some spots as columnar, and it is often intersected by curious hexagonally reticulated quartz or zeolitic veins, presenting sections on the surfaces of semi-detached blocks like those of basaltic columns, or the desiccation-markings frequently observed upon the surfaces of aqueous rocks, which are supposed to have been acted upon by the drying effects of sun and air. These may be frequently seen at Malabar Point.

Malabar ridge.

Further north, where the road from Bombay to Walkeshwur passes beneath the cliff upon which Castle Dangerous stands, the basalt is intersected by joints, leaving great pillars like enormous basaltic columns detached from the rest of the cliff, the intervening portions having no doubt crumbled away under the influence of the weather. Some of these, either owing to the same cause or some displacement of the softer strata beneath, have become inclined to one side or other; huge masses of polygonal or cuboidal form, doubtless separated in the same way, lie scattered about upon the slope at the foot of the cliff.*

Further northwards the bedding of the flows becomes more visible, particularly at the end of the hill facing the Vallade, and about its summit—the highest point in the Island, from which may be obtained a splendid view, including the whole of the Island of Bombay, the Islands

* Since the above was written many of these have been removed.

in the neighbourhood, the harbour and the fine mountains beyond.* At this place Malabar Hill proper ends; indeed the northern part is distinguished by the name of Kumbala Hill, but the same ridge, with a considerable interruption at the Vallade and a less one at the sluices, extends to Wurlee Point. Basalt of very similar character to that just now described may be found at low water about the little Island opposite to the Vallade, on which there is a Fakir's house; at Lovegrove, where the main drainage enters the sea; and all along Wurlee Hill, where its dip to the west gives a very regular and marked inclination to that side of the hill. Plate III is a view looking southwards from Wurlee Hill over the flats and the Vallade towards Kumbala Hill, the northern extremity of Malabar ridge.

At a little distance south of the village of Wurlee the basalt seems to lose its strongly basaltic character, or more probably other bands of concretionary, splintery, much weathered, and softer, trap beneath it become visible where the ground is low.

Shales near Back Bay.

Returning now to Malabar Point and proceeding along the shore of Back Bay, we find a reason for the abrupt scarp on this side of the hill in the occurrence of the fresh-water shales and flags. They appear first beneath the private road to the Governor's Lodge in a manner which suggests either that they thin out here naturally, or that a local depression in the whole group, including the overlying basalt, bends them downwards, so as gradually to disappear beneath the sea. From this point they appear in greater quantity as we proceed northwards, reaching in places a thickness of considerably more than 50 feet, without the upper part of the group being exposed owing to the covering of debris at the foot of the basaltic cliff.

* Near this place, at Mahalukshmee, the basaltic trap is rudely columnar.

That these shales pass inwards beneath the basalt so as to form a large portion of Malabar Hill might be presumed from the external appearances of dip in both rocks, and from what has been already said of the general structure of the Island; this is, however, proved to be the case by the discovery of the shales in wells and such sinkings through the basalt on various parts of the hill. Dr. Leith observed them exposed in this manner along the upper road to the Governor's Lodge near the last large bungalow on that road before reaching the gateway of the Governor's compound. He also kindly furnished the following information :—

Pass under Malabar Hill.

" Near the house lately occupied by Mr. Blay (close to where the height, 123 feet, is marked along the west shore of Back Bay), trap containing patches and angular fragments of shale was found in an excavation, from which also were taken pieces of the shale containing fossilized skeletons of frogs. Specimens of these shaly rocks may be seen in the parapet wall close by Castle Dangerous.

"Near this and at a short distance from the crest of the hill on the seaward side the trap was passed through in Mr. Cook's compound, and coarse shales were found beneath.

" In a well at the top of the long hill on the road from Chaopatee to Walkeshwur, and about 300 yards north of the entrance to the above-mentioned private road to the Governor's bungalow, 55 feet of shales were passed through and trap found beneath them. The shales were very fossiliferous, containing numerous skeletons of frogs, besides many plant impressions. As the height of the well at this place is not accurately known, a possibility exists that it may penetrate to a greater depth than the level of the sea, and thus reach a band of trap, weathered or ashy portions of which may be observed in situ along the shore." See also Dr. Carter's observations about this place, (Geological Papers on Western India, p. 143.)

In Dr. Buist's paper, page 171, Geological Papers on Western India, a foot note states that "a mass of diorite or greenstone, totally unlike the basalt of which the rest of the "ridge consists, was this season (1856) cut through on digging a well in a native garden "close by the entrance to the Government House grounds, at the further end of the village "of Walkeshwur. At the depth of 30 feet a pale-gray (alluvial) stratum of earthy looking rock was met with, exactly like that traversing Nowrogee Hill."

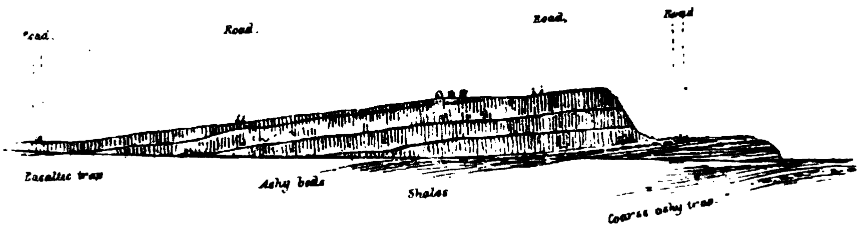
Those of the shale beds which we had an opportunity of examining were chiefly exposed along the shore below high water mark; they are

of light color, rest upon a coarse weathered trappean bed, and are much decomposed in places to a yellowish olive; they are very ashy in appearance, suggesting, as these rocks so frequently do, their being derived from trappean materials. They have a general low or undulating dip to the westwards, and contain, as usual, *Cyprides* and *plants.*

In the excavations being made at Chaopatee near this place for the reclamation of Back Bay, a considerable mass of trappean, flaky, deposited rock, containing large lenticular portions, is exposed; it has the usual westerly dip of 10° to 15°. Half a mile to the north-north-east of Chaopatee is the Gwala Tank, in which the shales also appear, and these, together with the associated ash, occur all along the eastern foot of Kumbala Hill, but there is considerable difficulty in the way of tracing them on account of the numerous compounds and the lower slopes of the hill being covered by detritus from above.

In one of the compounds on the end of the hill near Mahalukshmee, Dr. Leith informs us, the basalt was pierced by a well and the shales found beneath it; so that we may safely presume the structure of the hill to be such as the accompanying sketch represents :—

FIG. 1.—SECTION ACROSS MALABAR HILL.



At low water the little Island off the Vallade may be seen connected by a wide patch of dark rocks with the shore at Mahalukshmee, and long reefs also stretch from the Island towards Lovegrove Point. Upon examining these rocks near Mahalukshmee we cannot be surprised to find the flaggy fresh-water beds again lying nearly horizontal, but undulating a good deal, and to the westward, or in the direction of the general dip, overlaid, as usual, by the traps. The Island upon which the Fakir's house stands is higher than these horizontally undulating shales, and is composed of the overlying traps, which extending to the northward form the highest part and seaward side of Lovegrove Hill. At the sluices again the shales are exposed in the cut for the discharge of the main drain. They undulate, as they do at the further end of the Vallade, the part seen being from the axis of a very low and open anticlinal westward, exhibiting a dip of

Shales at Lovegrove;

at the Sluices.

FIG. 2.—SKETCH SECTION, SOUTH BANK OF THE SLUICES.

about 15° and less in that direction, but very little inclination to the east upon the other side of the curve. The shales seem to be thinner here than to the south, or else contain a considerable band of ash, which occupies the centre of the anticlinal curve. If the ash is to be looked upon as the lower limit of this band of shales, the thickness can only be about 30 feet, as the overlying trap with the same, or if anything a lower, dip, comes in at a distance of only a few yards to the west.*

The bluish-gray ashy rock which contains the patches of black shale is looked upon by Dr. Carter as intrusive, yet its appearance is not now like that of a dyke of any sort; on the contrary, a thin and probably lenticular band of dark olive and black shale appears to be interstratified with it and again overlaid by a considerable band of the ashy looking rock.†

The break through which the main drain passes into the sea is about 250 yards in width. Of this but a small portion is occupied by the shales on the south side of the drain, while they expand to the north—some irregularity, perhaps contortion, in continuation of the anticlinal shown in the figure, causing them to be exposed for a little way along a small cliff on the seaward side of the southern extremity of Wurlee Hill, but they pass beneath the basaltic trap of the hill within a few yards. Such irregularities in the outlines of boundaries of erosion are

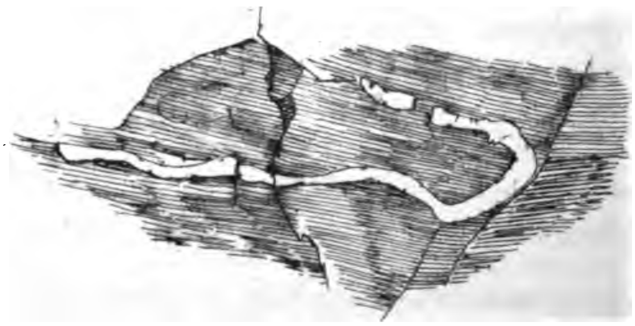
Wurlee Hill.

* The description of this locality given by Dr. Carter, who probably saw it to better advantage than ourselves, is very accurate. (See Papers on Western India, page 129).

† We have no reason from what is seen at the sluices to conclude that the base of the shales is exposed, and if the igneous rock which forms the centring of the anticlinal arch was supposed to have arrived at its present place in a sufficiently plastic state to flow, it might have taken up on its way projecting portions of semiconsolidated shale such as would be left by the erosion, which no doubt acted upon the surface over which it flowed. Such circumstances as caused the deposition of all of these shales would account for the occurrence of the dark olive and black shale layer containing *Cyprides*, which overlies the lower trap, and another flow, somewhat resembling the first, would produce all the appearances seen beneath the black shales represented in the cut.

as common as the undulations of the ground which produces them, and when any irregularity in a vertical direction occurs along the line of junction, this becomes, as a matter of course, exaggerated in plan. The shales here appear to have been so much crushed that it is almost impossible to follow their stratification. Appearances like those which occur here are frequently seen in fissile beds upon the slopes of hills, and are generally attributed to a superficial slippage called 'the fall of the hill.' A similar effect might perhaps have been produced by the weight of the overlying trap when it assumed its sloping position together with the shales, or when the overflow took place. The accompanying is a sketch of the appearance presented by part of a thin hard band which occurs amongst the softer shales at this place*,—the end of Wurlee Hill.

FIG. 3.—HARD BAND OF BROWNISH WHITE SHALE IN SOFTER BEDS.



* The shales all terminate so suddenly here that a fault is suggested by their ending, but the locality does not favor the tracing of it, so that the above has been considered the safest conclusion to arrive at from the evidence.

To the northward of this place the shales do not appear again on the seaward side of Wurlee Hill, but they may be frequently seen in the tanks, &c., at its eastern foot, in the same relative position as beneath Malabar Hill.* As is usual they have a slight dip to the westward, their outcrop following the irregularities in the form of the ridge and outcrop of the traps as elsewhere. This Wurlee ridge sinks where Wurlee Point commences, and in the lower ground some softer beds than the basaltic trap overlie the shales. The latter are well seen with their prevailing westerly dip of 15° to 20° in some deep open wells just south of Wurlee Fort. Further to the north near the Point, soft, red, ashy-looking, breccia appears upon the shore overlying soft, yellowish, and light-colored shales, of which 30 or 40 feet are exposed, the whole dipping at 12° a little to the south of west. The end of the Point is composed of the hard basaltic trap, with an undulating westerly dip.

Wurlee Point.

The flats, as might be expected, are extensively occupied by alluvium brought doubtless from the main land and deposited in the slackwater of currents setting between the islets, which, after elevation, became the hills of Bombay Island. Littoral deposits also occur, but none of the accumulations seem to retain their thickness or color over the whole of the flats if we except the recent conglomerate. The principal of these alluvial and littoral deposits are the brown kunkury clay so often

Flats of Bombay.

* Dr. Carter, at page 143 of 'Papers on Western India' states that everywhere underneath Malabar ridge the shales occur as an anticlinal; nothing to support this was seen except at the sluices, where somewhat of an open anticlinal curve has been described, but this much more resembles the undulating character of the beds outside the Vallade on the landward side, and on the seaward the general tendency of the Bombay rocks to dip westward. Dr. Carter gives the angles on both sides of this anticlinal as 40°, but this from what is now exposed seems much too high. Some false bedding or oblique lamination in the black shales appears to dip at a higher angle than the rest to the westward, but the general inclination, although unsteady as now seen, may be more safely estimated at below 20°.

seen along this part of the coast of Western India; a kind of blue clay containing mangrove roots, which may be a variety of the other; and the recent beach conglomerate (well called by Drs. Carter and Buist* littoral shell-concrete) which overlies the clay.

Dr. Carter seems to class all the clays together, and says "the color is brown above, blue below, and then yellowish;" the greatest thickness mentioned by him is 10 feet. The beach conglomerate or shell-concrete, he says, is found principally on the northern and southern shores of the Island, with an extreme depth of 20 feet, but it once existed at a place called Phipp's Hortos† almost in the centre of the Island, and it may be seen also near Seoree Fort, and occasionally in numerous other places about the flats. The shells which it contains are all of recent kinds found upon the neighbouring shores.

Shell-concrete.

Dr. Carter mentions the following genera, several of which we have also observed, *Cardium, Tellina, Turbo, Cerithium, Nerita, Trochus, Turritella,* and *Placuna.* Dr. Buist, who seems to have given the superficial deposits of the Island a great deal of attention, states that the lowest alluvium is the yellow kunkury earth, which, owing to the changes of level previously noticed, now occupies and forms the soil of many of the higher portions of the low lands, where red earth, (*lal muttee* of the natives, decomposed trap, &c.,) does not take its place: over this he places the blue clay containing selenite (sulphate of lime) and kunkur (impure

* Geological Papers on Western India, page 159.

† Attention has been called by Dr. Leith to a deposit of gravel near the sluices containing rolled and, as he suggests, transported pebbles. It was not noticed on the ground, and the pebble which Dr. Leith kindly showed us from it could not be identified with any very distant rock. Erratics are alluded to by Dr. Buist, at page 188 of his paper previously referred to, but we have seen nothing to establish the existence of any masses transported from a great distance; indeed this could hardly be expected, and all the fragments which go to make up the recent formations may have been derived from more or less local or neighbouring localities.

carbonate of lime), enclosing mangrove roots and masses of oyster shells; and above this is the littoral shell-concrete, sometimes loose in texture and sometimes very compact with all the shells replaced by crystalline carbonate of lime.

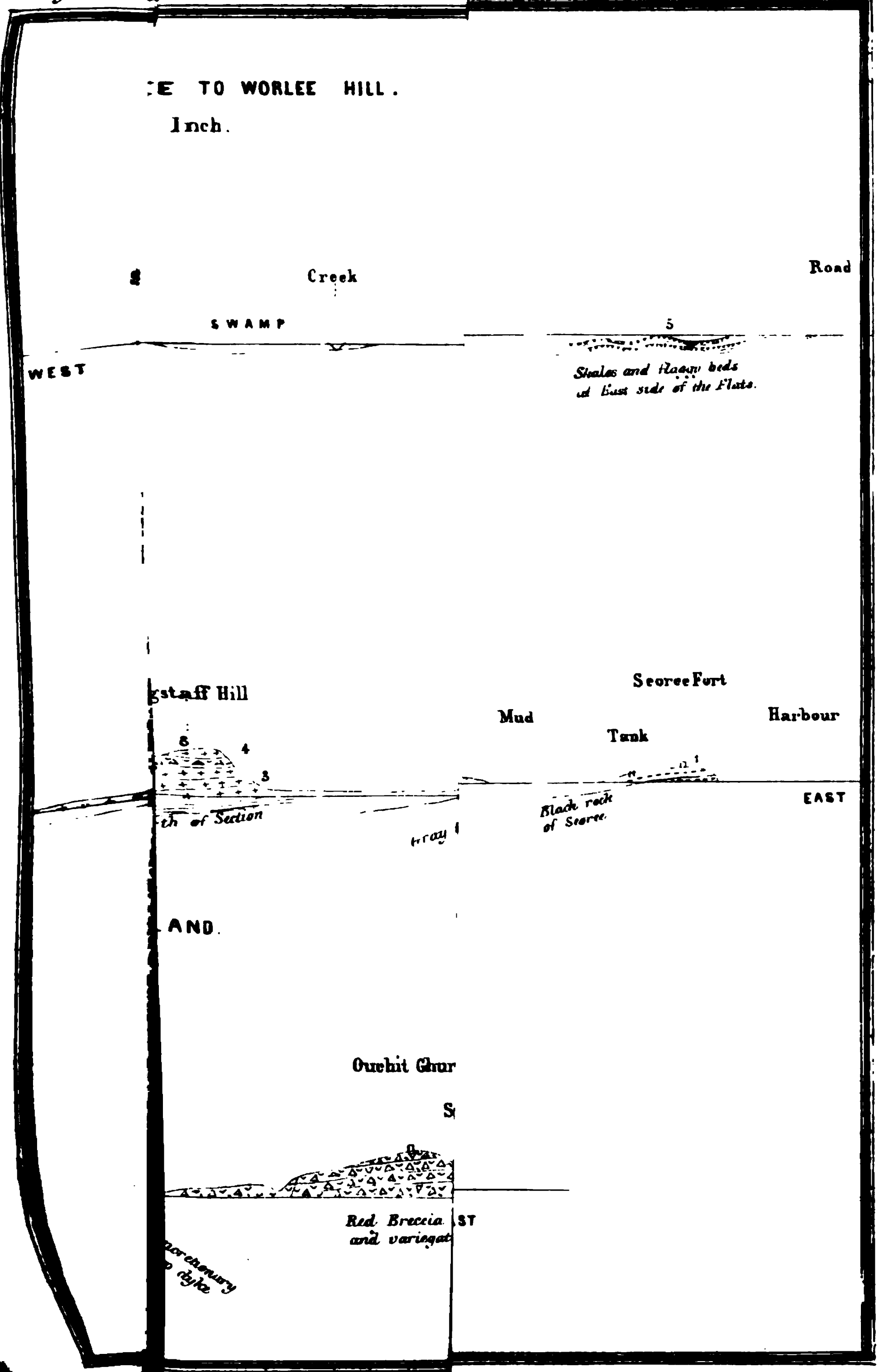
Red-earth.

As the most recent, or one of the most recent superficial accumulations, it will be sufficient to observe of the red-earth that it is plainly the result of the atmospheric decomposition of the trap which, under slightly different circumstances, or where decomposition has not proceeded for so long a time at one spot, results in the coarser accumulation called 'moorum'.

Blown sand.

Blown sand occupies a considerable space along the coast near Mahim, forming a low cliff or scarp; it appears to have been prevented from travelling further inland at a somewhat remote period by vegetation. A graveyard in the sandy scarp exposed in the monsoon of 1854, and covered by several feet of the sand, as is mentioned by Dr. Carter (page 161 of Geological Papers on Western India), indicates the antiquity of Mahim as an inhabited locality.

Wynne: B OF INDIA Plate II.



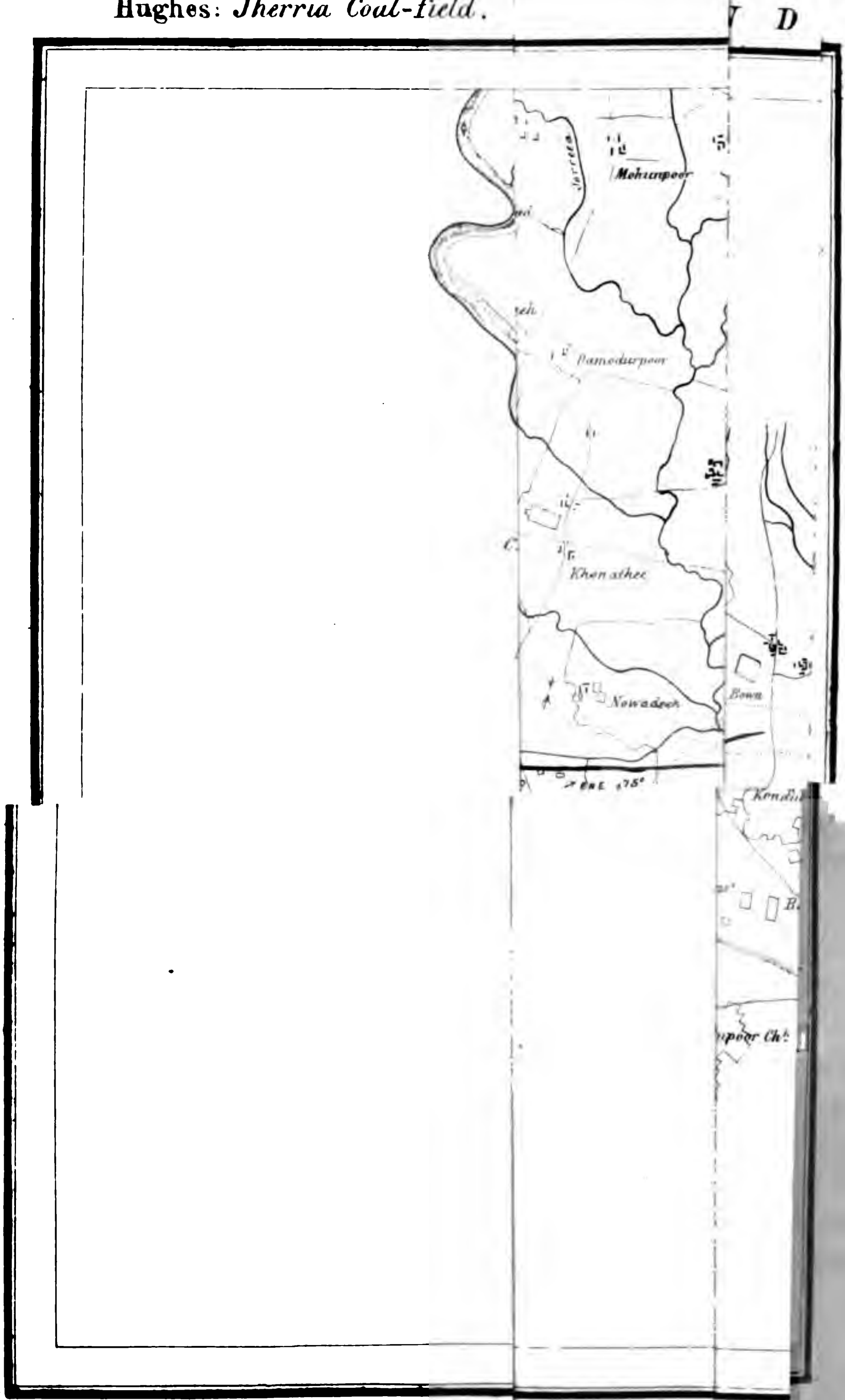
UTTA, APRIL 1865.

A. B. Wynne del.[t]   H. L. Fraser Lith.

BOMBAY ISLAND

Malabar ridge seen from Wurlee Hill.

Hughes: *Jherria Coal-field.*



On transfer paper by Bulioram Nath.

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MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

The JHERRIA COAL-FIELD, *by* THEODORE HUGHES, *Associate, Royal School of Mines,* F. G. S.

Few persons, beyond the circle of those enterprising men actually gaged there, are aware of the immense stores of mineral wealth which ist in that *valles opima* of Bengal watered by the River Damoodah, and ntaining within its limits an area of more than twelve hundred square iles of the rocks, which yield by far the greater portion of the valuable oal worked in India.

Nor is this area without great interest in the many questions which it opens out to the speculations of the scientific geologist. Such speculations and generalizations, however, ought to be reserved until the examination of the entire valley, now in progress, shall have been completed. The following memoir is therefore confined chiefly to a comparatively detailed description of the physical aspect and geological history of that portion of this valley to which we would give the name of THE JHERRIA COAL-FIELD, embracing an area of not less than two hundred square miles. At the same time allusions will necessarily be made to adjoining localities, when matters come to be discussed, which require illustration or confirmation by examples more conclusive than those which can be adduced from the district especially under notice.

Mem. Geological Survey, India, Vol. V., Art. 4.

The geographical position of this coal-field is easily indicated, inasmuch as it occurs only a few miles south and south-east of one of the highest and best known mountains in Bengal, Parisnáth. The field commences at a distance of about 170 miles from Calcutta, nearly south of the village and station of Gobindpoor on the Grand Trunk Road, and extends in an east and west direction for about eighteen miles, its greatest breadth, in a line north and south, being about ten miles. The exact boundaries of the field can best be seen on the accompanying map, to the scale of one inch to the mile. They correspond nearly with natural limits marked out by the physical outline of the country.

Geographical position.

Boundaries.

The general truth, that geological structure mainly determines the physical appearance of a country, is admirably illustrated and borne out in the present instance, the configuration of the surface of the ground presenting the same uniform type of aspect which is common in areas composed of coal-bearing rocks, and resembling in almost every detail the appearances exhibited by the Raneegunj field. The coal area generally is flat, and nowhere rises into undulating scenery. There is scarcely a single elevation worthy the name of a hill; only a few low ridges and escarpments, principally along the eastern and northern boundaries of the field, where the hard grits and sandstones of the lower, or Barákar, division of the Damúda series crop out.

Physical appearance.

District is flat.

From over the greater portion of the area the jungle has been cleared away, except in the neighbourhood and along the banks of some of the rivers. Its absence of course renders the examination of the district much easier than it

No jungle.

otherwise would be, but at the same time detracts very much from the appearance of the country, which does not present that picturesque and agreeable aspect that a well-wooded landscape always possesses.

Different scenery west of the Jummoonee.

A great difference, however, in the character of the scenery is seen in the area west of the River Jummoonee, due, not to any deviation from the normal type of appearance in the physical features of that part of it occupied by the coal measures, but to the ranges of metamorphic hills that rise on the borders of the field, whose steep and rocky sides are clothed with a rich and exuberant vegetation, and in the shelter of whose valleys clusters of lofty "Sal" are to be met with, contrasting conspicuously by the brilliant green of their foliage with the paler hues of the surrounding trees. Encircling their base, and covering the whole of the low level country to the banks of the Jummoonee, is a dense growth of jungle—dense in the true meaning of the word; and with the exception of those breaks where villages occur, the eye ranges over an uninterrupted view of magnificent woodland scenery that forms a striking and most agreeable contrast to the hedgeless paddy-fields and open wastes of the rest of the district.

Ground rocky.

The ground is usually rocky, and covered by a very slight amount of soil, so that cultivation is not extensively practised, and the villages, generally speaking, are poor and small in size, contrasting very forcibly with those that are situated on the gneiss, and other rocks of the altered series. Indeed, the test of comparative fertility and size of the villages might be employed to trace roughly the contour of the field.

Comparative fertility.

The drainage of the district is effected exclusively by rivers which rise in the metamorphic country.

Damoodah.

The principal stream is the *Damoodah*, receiving during its course as tributaries the *Jummoonee*, the *Kuttree*, the *Kurree*, and the *Chut Kurree* on its left bank, and the *Ijree* on its right. The sections in most of these streams are very good, especially that of the Jummoonee, which exposes the entire series of deposits from the lowest to the highest bed seen in the field, and conveys a more complete idea of the geological structure of the district than any other that can be pointed out.

Fine section in the Jummoonee.

Largest area drained by the Kuttree.

The largest portion of the area is drained by the *Kuttree* and its feeders, the *Khodo*, *Busraya*, and *Kummarjoors*. In one or two places the banks of the Kuttree are very pretty, and just above its confluence with the Damoodah its bed is worn into a succession of ledges over which the water falls from one to the other in several independent streams, producing a series of small cascades that add greatly to the general effect of the scene.

Kurree and Chut Kurree, shallow rivers.

The *Kurree* and *Chut Kurree* are shallow rivers, and do not exhibit continuous sections. They expose, however, much of the best coal in the field, and are important on this account.

Geology of the district.

As to the geology of the district, it may be stated in very general terms that two series are developed, the lower—the Talchir,—and the upper—the Damúda,—comprising a total thickness of 6,800 feet of strata, and forming a trough or basin, the beds usually dipping at right angles away from the boundaries, at varying amounts, towards a common centre of depression.

Beds form a basin.

Fault along southern boundary.

A large and remarkably well defined fault, possibly continuous or directly connected with the one that forms the southern boundary of the Raneegunj field,

cuts off the whole of the beds to the south, throwing them several hundreds of feet.

Talchir series.

The *Talchir* series is easily recognized by those peculiar mineral characters which serve so readily to distinguish it, where developed, in neighbouring localities. A 'boulder-bed' occurs at the base, and above it are flaggy green shales and mammillated sandstones, the former of which may be considered the distinctive rocks of the series.

Damúda series.

The *Damúda* series is characterised by its containing coal, by the mineral composition of its beds, and by the nature of its florà. In sub-dividing it, I have followed the classification and nomenclature first introduced by the Geological Survey of India, in the report on the Raneegunj field :—

1. Barákar group (at the base.)
2. Carbonaceous shales with ironstones.
3. Raniganj group.

No evidence of decided unconformity.

In the present instance, however, there is no evidence of decided unconformity between any of the above three groups, and my divisions are based entirely upon lithological grounds. Even this test, however, almost fails with respect to the carbonaceous shales with ironstones, as they are not developed to such an extent in the Jherria District as in the Raniganj field, and in many instances the ironstones are altogether wanting in the shales, so that they wholly lose their distinctive character.

Ironstones usually wanting.

No group higher than the Talchir and Damúda occurs in the field.

No formation higher than the two above mentioned occurs, and the Panchéts (the next in order of succession above the Damúdas) which possess such a splendid development at a distance of only 18 miles to the east in the Raniganj field, have been removed from this district,

so that no vestige of them remains. This phenomenon is no doubt in great part due to the fact that the southern boundary has not been thrown to the same enormous extent as that of the Raniganj field, although connected with it, and that therefore the Panchéts were less protected and more easily swept away by the denuding forces that acted against them.

Metamorphic series.

The metamorphic series, composed mainly of gneiss and constituting the bottom rocks of the country, is represented by a large inlier in the neighbourhood of Doomra, which must have been an island in the old Talchir sea at the time when the sedimentary substances which formed that group were being deposited, and, doubtless, furnished some of the material which we now see piled up against its old shores.

The most common varieties of rock are syenitic and porphyritic gneiss, but another very prevalent form is a binary compound of quartz and felspar. The last element is very subordinate, and as the grains of quartz are by no means sharply crystalline, this peculiarity, when the rock is much weathered,—and it occurs near the boundary of the coal-measures,—often at first leads one to the very natural supposition that it is an unaltered siliceous sandstone.

Having thus in a measure sketched out the physical appearance of the district, and briefly alluded to its geological structure, it will be as well to enter at once upon the main subject of the report, and describe in detail the development of the different series of beds, their relations to each other, and to the coal-bearing rocks of adjoining localities.

I.—The Talchir Series.

Throughout the whole of this area, the Talchir series presents the typical characters of the formation fully described in preceding memoirs, exhibiting that remarkable constancy of mineral composition, colour, and stratigraphical sequence of the beds, to which attention has been drawn by previous observers in other districts. It occupies but a comparatively narrow strip of land in the east of the field, its breadth scarcely exceeding 400 yards. This is due to overlapping on the part of the upper group; but beyond the Khodo, where the Damúdas have been removed by denudation, the Talchirs swell out to a distance of a mile and a half, and attain their maximum development in the neighbourhood of the Jummoonee. Several small patches crop out from under the overlying group of beds in various parts of the field, and although one of them is exceedingly interesting on account of the discovery of plants in it, the rest are too insignificant and obscure to be otherwise noticed than mapped.

Talchirs not well developed in the east of the field.

Best seen in the Jummoonee.

Directing our attention to the Talchirs, where they appear for the first time in the east, it will be seen that two small outliers occur near Sooroonga, in one of which Mr. Willson was fortunate enough to find some stems of plants. The beds in which he discovered them are very much decomposed, and it is difficult to say positively whether they belong to the upper or lower portion of the group. From the fact, however, of the occurrence of plants in them, it is probable that they are upper or transition beds, for the Talchirs, as a whole, as far as they have been yet examined, are, for the most part, devoid of any traces of vegetable life; and the few and questionable specimens which I myself procured were always in beds, showing a strong tendency to assume Damúda characters.

Two outliers seen near Sooroonga.

Plants.

Talchirs overlapped.

Following the boundary of the field northwards from Sooroonga, the Talchirs are entirely overlapped, and the lower Barákar shales impregnated to a considerable extent by iron, and dipping at an angle of 11° west by north, rest directly upon the metamorphic rocks.

This overlap, I believe, is due to the thinning out of the Talchirs, and not to denudation previous to the deposition of the Barákars, so that there is no proof of any lapse in time having occurred between the close of the formation of the one group and the commencement of the other; and consequently no unconformity.

Overlap no proof of unconformity.

Overlap is one of the necessary conditions involved in the successive deposition of any set of strata, provided that the land be sinking, and therefore, when taken singly, it cannot be assumed as a sufficient ground upon which to found the assertion that unconformity exists between two series of beds; although, when accompanied by some other feature, such as denudation, or difference of dip, it is one of the most satisfactory proofs of a break that could be desired.

The main body of Talchirs is first met with distinctly exposed in the Margottee Nuddee, near the village of Chandkoia. The section is not an extensive one; but as it is the first one in which the nature of the boundary between the Gneiss and Talchirs can be properly seen, and the characteristic needle-shales of the latter group are well shown, I have thought it advisable to give it.

1. At the base, and resting naturally upon, and not faulted against, the metamorphic rocks, is a conglomerate containing pebbles, chiefly of quartz and varieties of gneiss.

2. Green silt-beds, composed of very fine mud, and breaking up into small fragments.

3. Greenish-grey fine-grained sandstones, weathering with a mammillated surface.

4. Greenish-grey concretionary sandstones, portions of which are calcareous.

5. Green silt-beds full of small pebbles.

6. Conglomerate, somewhat similar to that occurring at the base of the section.

The remaining beds, in all likelihood sandstones, are concealed by mud and water. They do not, however, exceed 30 feet in thickness, as the grits of the Barákars crop out a short way down the stream. The average dip is 11° west-south-west.

The conglomerate noticed as resting upon the metamorphic rocks underlies the entire series as far as the Kummar, but west of that river, it is usually replaced by an extremely fine-grained brownish slightly felspathic sandstone, and this, again, in its turn by a modification of the conglomerate, which has been termed the 'boulder-bed', though more properly speaking, a coarse conglomerate, presenting some very interesting features, which has drawn a large amount of attention from every observer who has treated of the Talchirs.

Boulder bed.

It consists mainly of masses of gneiss and quartz, some of which are exceptionally large; the average size, however, of the generality of the blocks does not exceed 1 foot in length and 3 to 4 or 6 inches in breadth. The whole are imbedded in a matrix varying in texture from a coarse-grained siliceo-argillaceous sandstone to that of the finest silt, and it is due to the fact of the intimate occurrence of such fine detrital matter with large masses of rock, that speculations have been hazarded as to the part played by ice in the formation of this bed. Bearing in mind the general laws of the distribution of detritus, one is at a first glance apt to attri-

Composition of boulder bed.

bute to the agency of ice a share in the transportation of the larger blocks. On carefully examining the evidence, however, I think there is none that can justify any hypothesis being maintained which necessitates the existence of climatal conditions during any part of the Talchir epoch so diametrically opposed to those obtaining at the present day in these latitudes, or even during the succeeding coal-bearing period of the Damúdah age.

No evidence of an ice-period in the Talchirs.

No scratchings or groovings on any of the stones, nor any of those familiar signs by which the action of ice is so characteristically marked in the Permian breccias and glacial deposits of England, are to be met with, and the evidence is strongly in favour of the suggestion made by Mr. Williams, that the boulder bed is an ordinary shore deposit. None of the dèbris differs in composition from that of the gneissose or other varieties of metamorphic rocks upon which it rests, and there is no reason for supposing, either from its appearance or any other circumstance, that it was derived from very distant sources. The small pebbles are well worn and rolled, but the larger blocks sometimes retain almost the primitive form in which they were broken off from the parent mass.*

* During a short visit that I paid this year to the Straits Settlements, it struck me that the conditions under which the boulder bed was formed were very similar to those now influencing the formation of some of the beach deposits which I examined. Specially referring to the Island of Penang, I may say that it consists mainly of syenitic granite, rising in many places to a height of 2,000 feet above the level of the sea. It is separated by a small strait from the main land, and the tide flows alternately north and south at a moderate rate, rising and falling a few feet. The beach is slightly inclined and covered either by a very fine felspathic mud or sand, in which huge subangular syenitic boulders, outrivalling those of the Jherria field, mingled with pebbles of smaller dimensions, are firmly imbedded, presenting altogether as close a resemblance to that of the boulder bed as can possibly exist. The boulder bed is evidently a beach deposit that took place when, doubtless, numerous metamorphic islets dotted the surface of the Talchir sea. The waves, gently rolling in, rounded the smaller pebbles, whilst chiefly to atmospheric agency and the tendency which most Indian gneiss exhibits to weather into spherical shapes, we must set down the apparently rolled and water-worn condition of the larger boulders.

Between the Margottee and Chut Kurree rivers the Talchirs are not well exposed, but they are easily recognised by that never-failing accompaniment of flatness in the aspect of the ground that they occupy.

In the Kurree Joor the conglomerate occurs as usual at the bottom. It is not very distinctly seen in the river, but a little way inland on the right hand side to the north of Mutkooree glimpses of it are obtained. The section, however, is chiefly remarkable on account of the fine development of the silt-beds or needle shales which, are the true 'stamp rocks' of the series. Nothing can be more satisfactory for the purpose of establishing the existence of the Talchir group than the discovery of these shales, their wonderful persistence both in colour and general composition having enabled observers to recognise them instantly in whatever part of India they were met with. They are usually yellowish, green, or purple in colour, and composed of very fine silt, in which the argillaceous element predominates over every other; a considerable quantity of silex, nevertheless, enters into their composition, and imparts to them a flaggy structure. Their chief peculiarity is the ready manner in which those that have been exposed to weathering at the surface break up, upon giving them the slightest tap, into sharp fine fragments assuming a more or less acicular form, whence the name of needle shales. These rocks form the main mass of the Talchirs, and cover a considerable area of ground in the north-western portion of the field. Around the villages of Bhimkinaree, Doomra, Hurrina, and Khanoodeeh, they contain numerous pebbles and boulders. Near Chaieta they may be very advantageously studied, as some extremely fine sections of them are seen there.

Needle shales.

Pebbles in the needle shales.

Passing westwards from the Kurree Joor, favourable opportunities occur for definitely determining the nature of the boundary. Throughout the whole of its course it is natural.

South of Bhoolee and east of Rangainee there are two small outliers of the Talchirs, consisting of fine yellowish-green flaggy shales similar to those just referred to. One of them is too small to insert on the map, and it is only the more easterly of the two that is noted.

An exceedingly clear and complete section is seen in the Bhoolee Nuddee, exhibiting the sandstones constituting the upper portion of the group.

At the base resting on the gneiss,

	Ft.	In.
1. A greenish felspathic argillaceous matrix, containing pebbles of all varieties of metamorphic rocks, with a few large boulders	3	0
2. Greenish-yellow argillaceous beds in which the lines of bedding begin to appear. Dip 35°	17	3
3. Yellow or greenish-yellow soft concretionary sandstones, dip 18.°	21	0
4. Beds hidden: calculated thickness	17	0
5. Beds similar to lower conglomerate	24	0
6. Olive-green flaggy shales	27	0
7. These shales become coarser grained and assume a concretionary structure. Dip 18.°	58	0
8. Highly felspathic quartzose sandstones	22	0
The river here runs from east to west along the strike of the beds.		
9. Argillo-arenaceous sandstones containing pebbles ...	18	0
10. Open, coarse-grained yellowish sandstone containing nests of pebbles	12	0
11. Micaceo-argillaceous shale	4	0
12. Carbonaceous shale	2	0
13. Felspathic slightly calcareous yellowish-grey sandstones ...	20	0
Total ...	245	3

The sandstones are better developed in this part of the field than elsewhere. They usually occur towards the top of the group, seldom at

the bottom. In composition they vary from coarse highly felspathic sandstones to fine siliceo-argillaceous sandstones. These latter often assume a mammillary structure that is very characteristic of them, and serves generally to distinguish them from sandstones of somewhat similar composition occurring at the base of the Damúda series.

Mammillary structure of the sandstones characteristic of the Talchirs.

No feature of peculiar interest is seen in the Busraya Nuddee, the section being identical with that of the Bhoolee Joor. In the Busjooreea, however, small ridges of gneiss stand up through the Talchirs, so that the original surface of deposition of the latter is well seen. The gneiss has been eaten into, forming pockets in which the conglomerate is deposited. The section is—

a. Metamorphic rocks.
b. Talchir.
  1. Conglomerate bed.
  2. Flaggy silt shales, breaking up into small angular pieces.
  Dip 32° S.
a. Metamorphic ridge of hornblendic gneiss.
b. 2. Fine grained greenish siliceous shales.
a. Metamorphic ridge of hornblendic gneiss.
b. 1. Conglomerate.

From this point the section can be measured, as there is no repetition of beds. The rocks consist of flaggy shales and mammillated sandstones, including in all a thickness of 180 feet.

The occurrence of lime has not been specially referred to, but it enters frequently into the composition of the different beds. Limestone nodules, more or less flattened and arranged in regular bands, are found at intervals. They owe their origin entirely to segregation, and were not deposited through any mechanical agency. Argillaceous concretions that may contain a small quantity

Lime.

Nodules the result of concretionary action.

of lime, but do not effervesce on application of acid, occur in some of the shales, more especially those in the neighbourhood of Mohleedeeh.

The conglomerate does not extend beyond the two villages of Nuggree, and is replaced in the Kummar Joor by slightly purplish silt shales dipping at an angle of 32° to the south. Opposite Kutras the Talchirs are reduced in thickness, and are only interesting because in the Kuttree a bed of a somewhat carbonaceous character occurs: one of the very few examples of any such met with in the series.

Carbonaceous shale in the Kuttree.

West of Kutras there are small outlying patches of Talchirs bent up (as is the case at Rangainee) with the gneiss. They may be, and indeed look, as if they were let in by small faults, the country here being full of runs of quartz-breccia, which are usually assumed to be indicative of dislocations or cracks.

Breccia.

An extensive run of 'breccia' stretches from Kutras to Derda, apparently filling up a line of fault between the Talchirs and gneiss. A little section, however, south of the Derda tank, shows that this is not the case, and that the breccia is confined entirely to the metamorphic rocks, a band of gneiss several yards in breadth, intervening between it and the Talchirs.

Inlier of gneiss.

West of the River Khodo, an inlier of gneiss is exposed by denudation, and a greater spread of Talchirs is seen, consisting mainly of fine silt shales. The dips on an average are small. About Hurrina and Busooreea they do not exceed 4°, and near Nurrainpoor the beds are nearly horizontal.

Jummoonee section.

The best and finest section in the whole field is that of the Jummoonee. The 'boulder bed' dipping east-by-south occurs for more than a mile along the strike of the river, and is beautifully displayed. The colour of the

matrix is a bluish-green, and it contains throughout small quantities of lime. The section somewhat generalized is as follows :—

		Ft.	In.
1.	Boulder bed. The matrix usually green or yellow, but bluish-green in the Jummoonee. The largest boulders are red felspathic gneiss.		
2.	Fine olive-green silty shales breaking into small acicular pieces, and containing boulders not much water-worn. The transition between the amorphous boulder bed and these shales with stratification is very plainly marked. Dip 25.° E. S. E. by E.	63	0
3.	Bluish-green siliceo-felspathic matrix, containing, scattered through it, sub-angular pieces of quartz and boulders 3 to 5 feet long. Bands of pure silt beds occur. Dip 8° to 10°	15	0
4.	Bluish-green flaggy beds, containing boulders scattered through them and not in regular layers	82	0
5.	Boulder bed	13	0
6.	Greenish looking beds, whose upper surfaces present a scaly appearance. They possess a silky lustre from the carbonate of Lime in them. Nodules of lime frequent throughout	28	0
7.	Purplish leaden-grey shales, breaking into acicular pieces, and containing lime. Dip 10.°	17	0
8.	Yellow very fine-grained sandstones containing pebbles and boulders	8	6
9.	Purplish leaden-grey shales, with bands of pebbles at intervals	43	0
10.	Yellowish-green shales, alternating with very fine grained sandstones; calcareous bands at intervals	102	0
	Strike S .E. by S. to S. S. E.		
	Massive sandstones containing throughout boulders and bands of small pebbles	20	0
	Boulder bed (near the ghat between Khanoodeeh and Tooroonga)	46	0
	Green felspathic and siliceous sandstones	78	0
	Sandstones of various colours, green, brown, and white, some of them calcareous	80	0
	Fine siliceous sandstones, with shales containing calcareous nodules	96	0
	Dip varying 10°, 8°, 5°.		
	Greenish siliceo-ferruginous shales having a botryoidal weathered surface	48	0
	Total ..	739	6

The next beds are not plainly seen. They form the transition between the two groups, and appear to be mainly pebbly conglomerates and greenish siliceous sandstones.

The total thickness of this section, making an allowance for the upper beds, is about 780 feet; and, as exhibiting the character of the series when well developed, it cannot be surpassed. The boulder bed at the base is difficult to measure, owing to the absence of any distinct dip. It probably exceeds 30 feet in this particular place.

Breccia forming boundary.

West of the Jummoonee, a strong 'quartz-breccia' forms the boundary near Tooroonga, Kurreedoogdah, and Gootway. The same is the case south of Guteeara, where the thickness of the Talchirs is slight. The dips are not constant in direction and amount, and it is probable that the entire district about this neighbourhood is cut up by faults. The boulder bed and conglomerates are absent, mamillated greyish-green sandstones and olive-green shales forming the greater mass of strata.

Talchirs near Parbad and Kareetand.

In the south-east corner of the field, near the villages of Parbad and Jugankocha, a little patch of Talchirs not exceeding 100 feet in thickness occurs.

An imperfect section is seen in the Chût Kurree Joor.

Another small area of them occurs west of Kareetand.

Regarding the boundary of the Talchirs and Barákars, there is a marked difference in the lithological character of the two groups when looked at through the medium of their respective stamp rocks. But when we attempt to draw an exact divisional boundary between them, taking mineral composition as a basis of separation, it is often times a matter of some difficulty.

Mineral constituents of both groups derived from same source.

The mineral constituents of each group appear to have been derived from the same source, the immense quantity of felspar, the peculiar aspect of many of the sandstones, and the composition of the boulders and pebbles scattered throughout the whole of the beds, all pointing to one origin, namely the surrounding metamorphic country.

No direct unconformity is seen as far as dips are concerned; and the determination of the upper limit of the Talchirs is in many of the sections, although on the whole exact, only an approximation.

No unconformity of dips.

No good specimens of any fossil plants were procured. Indistinct carbonaceous markings are abundant in some of the fine argillo-siliceous sandstones occurring in the Khodo, but all quite fragmentary and too indistinct to be recognised. A few impressions were found in the Busjooreea, one of which perhaps can be referred to the genus *Glossopteris.*

No good specimens of fossil plants.

Coal has up to the present time not been discovered in the Talchirs. A few beds of slightly carbonaceous shale, however, occur occasionally. This should be borne in mind as evidence to show that the conditions fit for the development of vegetable life did not start suddenly into existence with the first advent of Damúda times; and that possibly coal (the absence of which from the Talchir group has been one of its specific characters) may yet be found in it.

No coal as yet discovered in the Talchirs.

The traces of a fauna are very slight, only a few annelide tracks north-east of Nowadeeh having been discovered. Some pitted impressions (which, however, cannot be mistaken for footprints) occur in the green silt shales south of Dhunbad.

Only traces of a fauna.

Dykes which are frequent throughout the Raniganj field, cutting through Talchirs and Damúdas, are, in this area, wholly confined to the latter group with the exception of two.

Even the large dykes, 50 and 60 feet broad, running across the Khodo near Baihyardeeh, die out before they reach the Talchirs.

2.—The Damuda Series.

This series, whose value economically has caused special attention to be devoted to it, occupies the remaining portion of the field. It has been divided into a lower, middle, and upper group, *viz*:—

(a) Barákar, or lower group.

(b) Carbonaceous shales with ironstones, or middle group.

(c) Raniganj, or upper group.

Data not clear for separating the 3 groups of the Damúda series.

The data, as I have previously said, for making this separation, are not at all clear in this field, and even in the Raniganj District, where it was first made, the grounds for doing so are only evident with respect to a division between the lower and middle groups. Mr. Blanford, in his report of that area, states "that no clear evidence of the unconformity of the upper group upon the ironstone shales has been met with; but that at the base of the ironstones, there is a slight break of continuity between them and the Barákars." The unconformity is probably of very small amount, for the general strike and dip of the series is the same. The fact of overlap of the one by the other is also urged as some proof of unconformity. But mere overlap is no argument for a natural division; and even a change in mineral character may accompany it under circumstances requiring but a slight modification in the operation of the causes then existing, so that should these two phenomena,—an overlap and change in mineral character,—accompany each other, independently of other evidence, they may, however suggestive of the contrary, afford no proof of a break in time.

In the Jherria field, the different groups of the Damúdah series exhibit no distinct unconformity, and their boundaries were determined almost purely by lithological evidence.

The carbonaceous shales with ironstones, although poorly represented when compared with those in the Raneegunj district, serve in a great measure, to define the limits of the Barákar and Raniganj groups, their composition and the entire absence of coal from them being some sort of guide by which to judge where the one group commences and the other terminates.

Three distinct periods.

Looking at the series from an economic point of view three distinct periods can be made out: one during which coal was being formed (the Barákar); a second during which the special physical conditions favourable for its formation did not exist, (the carbonaceous shales;) and a third when favourable circumstances again set in (the Raniganj). The first of these embraces a thickness varying from 2,700 to 3,000 feet; the next 600 to 700; and the third, where most fully developed, about 2,200.

The Barákar series.

The Barákars possess the same lithological composition here as in the Raneegunj district, and it is evident that they are the true equivalents of the beds seen there. The characteristic beds are the carbonaceous shales (or rather shales blackened by an admixture of carbonaceous matter) and the felspathic grits and sandstones at the base, these latter owing their importance rather to the steady manner in which they stretch from one end of the field to the other than to their thickness. Holding an almost equally important place are the coarse and fine grained felspathic micaceous sandy shales containing pebbles and boulders; subordinate to these are ordinary siliceous sandstones and seams of coal.

As a whole, the Barákar can be looked upon as a shaly group, thick bedded sandstones being more frequent at the base than towards the middle and top; sandy shales, carbonaceous shales, and shaly sandstones making up the greater thickness of beds.

The carbonaceous shales with ironstones require no description; their lithological composition being sufficiently indicated by their name. They are not, however, wholly shaly, several beds of sandstones occurring at intervals throughout them.

The carbonaceous shales with ironstones.

The Raniganj or upper group retains in a measure the same character as the Barákars; it is not so essentially shaly, and although containing none of the coarse felspathic grits and sandstones which distinguish that series, thick-bedded sandstones frequently occur. The texture of the particles forming the various rock masses is more uniformly of a fine-grained nature, and we do not see such sudden alternations of coarse sandstones, conglomerates, and shales, as in the lower series. The most characteristic beds are yellow slightly calcareous sandstones which almost invariably crop out, even when no other rocks do so. Their weathering is that peculiar to stones containing lime, and the lines of alternate deposition are in many instances remarkably well brought out. They occur also in the Barákar group, but not in the same abundance as in the present series of which they may be received as a tolerably sure indication.

The Raniganj group.

The Raniganj rocks as developed in the Raneegunj district were not, until the present field was examined, known to occur positively elsewhere. Their existence, however, has now been established not only in the Jherria field, but also in the Bokaroh, Ramgurh, and Hoharoo fields, all of which have been visited by myself, and there is little doubt but that they will be found still further west in the Palamow district.

The Damúda rocks extend all the way up the valley of the Damoodah.

The ironstones and Raniganj rocks are well seen in the Bokaroh field, and there can be no hesitation in referring them to the corresponding series of the Raniganj field.

(a.) THE BARAKAR GROUP.—The Barákar group covers a larger area than either of the other two, owing to the smaller angle of inclination at which the strata composing it dip. In the east of the field the beds are well developed, and they occupy nearly the whole of the area north of the River Damoodah. Proceeding westwards they are wholly confined to its left bank, and the width of the field becomes more contracted. But the dips being high, nearly the same thickness of strata is developed as farther east.

In the east beds well developed.

Coal is found at all depths. The larger seams are, however, generally near the base; those occurring about the middle and towards the top of the series being usually of small thickness. Their character for irregularity, which was established in the Raneegunj field, is well borne out by a comparison of the various sections made in the different nullahs and streams of this district. Scarcely one exhibits a steady thickness for a quarter of a mile along its strike, and even at shorter intervals the partings of sandstone or shale are never constant, so that the attempts to trace them out for any distance have almost invariably failed through the difficulty of recognising them in fresh sections.

Coal found at all depths.

Seams irregular.

The places where coal seams are found in the group will be fully noticed as the description of the rocks proceeds from east to west.

Commencing the local descriptions of the group near Sooroonga, we find that the lowest strata consist of a small thickness of carbonaceous and sandy shales, succeeded by coarse brownish-grey sandstones and grits, which latter rocks form minor elevations, presenting a curious aspect owing to the sub-angular quartz stones falling out from the matrix of the rock and strewing their sides, imparting to them a whitish appearance. This

Rocks near Sooroonga.

is better seen in the pudding-stones and very coarse grits of the Jummoonee, and the lithological character of the hills can be recognised at a considerable distance by means of their snow-like covering.

Carbonaceous shale.

Section in the Parbad Nullah.—At the source of the Parbad Nullah a very prominent bed of carbonaceous shale occurs, which has been noted on the map to serve as an index of position. It is distinguished by a dotted instead of a full black line. Proceeding down the nullah another large bed of carbonaceous shale crops out just east of Jeenagurha. The bottom part, 1' 0" to 2' 0", is coal of very poor quality. From this point to within 20 yards of the Chut Kurree Joor no seams are seen; black soil shows occasionally, but as this is equally due to carbonaceous shale and coal,* no judgment can be passed as to its exact nature.

Change in strike.

Immediately west of Parbad, the beds exhibit a change in strike, being south-south-west, north-north-east; dip west-north-west 15°, instead of a nearly north and south strike as near Sooroonga.

Coal seams near Teesrah.

Section of the Margottee Nuddee.—Coal first appears a little above Teesrah, being a seam 2 feet thick. A few feet higher comes another measuring 11 feet, which is exposed several times owing to the bending backwards and forwards of the river. The dip is low, not more than 5° to 7° west by north, which would be very favourable for working. The quality of the coal, however, is too bad to render it valuable. The upper portion of it has been on fire.

Another seam, the last one, crops out in the Teesrah ghat, and runs, more or less, along the course of the nullah. The breadth

* In discriminating between an outcrop of coal and carbonaceous shale, I have invariably found that the pieces of coal are rough, and squarish in shape, whereas the carbonaceous shale breaks up into thin angular fragments with conchoidal surfaces very much like the silt-beds of the Talchirs.

of its outcrop was hidden by water, but it was plainly enough seen to show that it was of considerable thickness. A few lumps have been cut out of it by the natives around, but they prefer going to the Chut Kurree Joor, where the quality of the coal is much better, being less shaly.

Coal at Jeenagurha.

Near the deserted village of Jeenagurha a seam occurs close to the tank, which is probably identical with the one seen in Teesrah ghât. Like very many others it has been on fire.

Ignition owing to presence of iron pyrites.

There appears to be a general tendency in all the coal seams of this group to ignition, owing, most probably, to the presence of iron pyrites in them, which gives rise to spontaneous combustion. The metamorphism which is produced in the shales either above or below, or belonging to, the seams is very varied. Sometimes they are converted into well-burnt bricks, either of a red or white colour, according as they contain a larger or smaller quantity of iron. Under slightly modified conditions, they become a rough vesicular looking rock, with a variegated leaden and brownish grey colour, very hard to break under the hammer. When they assume this latter form, they invariably produce a ridge indicating the line of outcrop of the seam, several of which lines occur at various places in this field. Some of the more marked are two or three near the town of Jherria, and one west of the village of Gurreea.

Section of the Chut Kurree Joor.—After the Margottee the next river is the Chut Kurree Joor. The lowest beds of quartzose felspathic grits and sandstones are very well seen in it, and form, as usual, a series of low elevations following the general contour of the field.

Near Bustakola the river runs in an easterly direction, exposing a seam for about half a mile along the outcrop. It is made up of a mixture of shale and bad coal, and its total thickness is rather above than below

50 feet. This has also been burnt in one portion, and the clinkered shales have prevented the bank of the river in that particular place from being lowered to the same level that it has elsewhere.

Coal at Bustakola.

Above this large seam comes another, cropping out in the bend of the river just above Futheepoor, measuring 6 feet. It has been worked to a slight extent, but abandoned on account of its inferior quality.

Coal near Futheepoor.

The beds at this point become crumpled, and change their dip from south-west to west.

The next seam can be traced for a long way, its outcrop coinciding with the course of the river. Its thickness is 9 feet, and the angle of dip varies from 6° to 10°: in some places, however, there is no dip. The quality of the coal is good, an average specimen having a brownish-black appearance; and the bright shining laminæ being nearly in equal proportion to those of a duller lustre. It is free from iron, the ashes giving no indication of its presence. Trap occurs in the seam.

Good coal.

The succeeding beds are chiefly sandstones and carbonaceous shales, with numerous impressions of *Glossopteris*. Opposite Lodona, there are two seams, the lower measuring 1 foot, and the higher 4 feet 8 inches; its section from bottom to top is—

Coal opposite Lodona.

				Ft.	In.
Coal	...	..	...	3	0
Parting	..	..	..		4
Coal	..	..	..	1	4
	Total thickness of seam		..	4	8
	Total of *coal*	...	..	4	4

In appearance the coal closely resembles that of the 9 feet seam, and an assay of it may be taken as fairly representing the two :—

Volatile	26·0
Fixed carbon	63·0
Ash	11·0
	100·0

The seam next to this, one of 4 feet 8 inches, is seen twice; the last time at the Ghat between the villages of Jyrampoor and Brahmunburraree. The dip is 7° west by south, and the section in descending order is—

Coal near Jyrampoor.

	Ft.	In.
Coal (stony)	3	6
Slaty shale		4
Coal (good)		9
Reddish carbo-ferruginous shale		4
Coal (of pretty fair quality)	2	1
Arenaceous shale		2
Coal		6
Arenaceous shale		4
Coal		8
Total thickness of seam ...	8	8
Coal	7	6

Although containing 7 feet 6 inches of coal, the quality is too poor to render this seam of any value. The next, however, is better, and is cut into extensively. The dip is slight, ranging between 5° and 7°; the total thickness of the seam is 13 feet. The coal varies in quality, but it may become more uniform as it is sunk into, and further removed from the deteriorating action of surface weathering. Coal must necessarily be materially affected at its outcrop, but it is an erroneous supposition, which nevertheless is often entertained, to imagine that in proportion to the depth we go, the quality of the coal improves, and therefore that any seam, however bad it may be found at first, will eventually on sinking deep enough become good.

This seam is the highest in the group, as seen in this river, and the next beds exposed are lower. The change in strike noticed in the Parbad

Nullah extends to this one, and the seams that occur near the junction of the two streams dip to the north-west, increasing in amount from 15° to 45° and 50°.

Probable fault.

A fault very possibly crosses somewhere near this spot, but no positive proof of it could be obtained, although the rocks are pretty well exposed. The seams of coal which are seen, are not represented in any part of the upper course of the Chut Kurree Joor, where they ought to be if they were continued and not cut off. Knowing the irregularity of the Barákar seams however, it may be assumed that they die away naturally at a short distance from where they crop out instead of having been broken by a fault. The first of these seams occurs 130 yards below the junction. The section of the whole, three in number, is—

		Ft.	In.
1st.	Seam	16	0
	Intermediate carbonaceous shale ..	3	0
2nd.	Seam	15	0
	Intermediate black carbonaceous shale ..	5	6
3rd.	Seam (indistinct)	11	6*

Coal north of Nonoodeeh.

A very crushed seam, in which all traces of bedding are obliterated, occurs where the small stream north of Nonoodeeh joins the Chut Kurree. Just below this the river passes through metamorphic and Talchir rocks, and does not give any further section of the Barákar group until it approaches the village of Chasnala in the south-east corner of the field. As this portion of the area will be spoken of separately, the seams occurring there will be noticed subsequently.

Between the Chut Kurree and the river west of it, the Kurree, the indications of coal are very scant. Scarcely an outcrop is visible, and

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* The high angle at which these dip, 45° to 52°, precludes them from being worked as long as much more favorably situated coal occurs.

after a most careful search only four or five small seams, none of which were of any value, were discovered. One near Brahmunburraree, another near Nonoodeeh, and three near Hurriladeeh.

Pebbles common in the Barákars.

The occurrence of pebbles and boulders in the Barákars is very common. Near Nonoodeeh and in the neighbourhood of Jyrampoor, Jeealgurha, and Hurriladeeh, the surface of the ground is strewn with them. They consist mainly of quartz, and vary in colour from white to green, blue, grey, and red. The beds in which they occur most frequently are fine grained, thin bedded, light grey felspathic siliceous sandstones weathering with a coarse open aspect, and usually stained in some degree by iron. They are not, however, confined to any particular rock, and were found even in carbonaceous shales near Jugta, a village standing on the banks of the Busjooreea Nuddee. In the northern portion of the field between Mutkooree and Bhoolee the sandstones at the base of the series are full of them.

Coal south of Dhunbad.

Section in the Kurree.—In this river the first seam of coal occurs about one hundred and fifty feet above the highest bed of the Talchirs, and is 3 feet thick, with a dip of 12° south-west as nearly as it could be determined. Its quality is not so good as some coal further down the stream, but as it is the most accessible, it is used for burning the kunkur employed in the building of the bridges on the Ranchee Road. It is let in for about 20 yards of its outcrop by two small faults.

Between the two bridges a worthless seam crops out and extends some way to the west; another small one occurs on the south side of the last bridge.

To this succeed coarse-grained quartzitic sandstones, many of them felspathic. Carbonaceous shales are rare.

Then comes another seam of large size and of indifferent quality, dipping at an angle of 10°. On the west or right bank of the river it

is much crushed, and furnishes an example of one of those confined local disturbances affecting merely a few beds which are common throughout the field.

About 30 to 40 feet higher in the series is the next seam, 5 feet thick. It is very inferior and appears to be mostly shale. Scarcely any of it is free from iron, which occurs in a pisolitic form, and also in thin layers or flakes of pyrites coating the sides of joints and cracks.

Nayadeeh seam.

After passing over some siliceo-felspathic sandstones another seam occurs near Nayadeeh. The section from bottom to top is—

	Ft.	In.
a. *Coal*	6	4
b. Coaly shale	4	0
c. *Coal*	4	0
d. Shale		8
e. *Coal*	2	10
Total of seam ..	17	10
Total of *coal* ..	13	2

The rest is not good, its appearance being slaty and ferruginous.

The best coal is (*c*); it exhibits ball structure. A small dyke cuts the seam.

Coal at junction of small feeder.

The river next passes through flaggy sandstones, sandy shales, and coaly shales, with bands of yellowish and reddish ferruginous concretions. A small rivulet meets it north of Koosoonda, and a thin seam, 8 inches, is exposed at the junction.

The succeeding beds are carbonaceous shales, some of them coaly; but not sufficiently so to be dignified by the term coal.

Seam injured by trap.

Three hundred and twenty to three hundred and fifty yards down the river from the small feeder is a large seam much injured by trap, which ramifies through it in every direction and renders the coal useless. Its thickness is about 20 feet.

One hundred and twenty yards from this another is met with, which in quality surpasses that of any other in the district. I would hesitate to pay this unqualified testimony as to its superiority were I not convinced that such was the case. Its external appearance is every thing that could be desired, a black shining lustrous look, with a marked preponderance of the fatty layers. From the mere experience of having it burnt before my tent, I am enabled to state that it cakes in the open air, and requires frequent stirring to prevent it from binding. This property is one so rarely exhibited by Indian coals that it deserves to be specially noted, and it is to be hoped that when this seam is worked, it will be found to retain its character throughout its whole depth. During combustion it gives out a copious supply of gas, burning with a rich yellowish-white carbureted flame. It will, in all likelihood, turn out to be an excellent coal from which to manufacture gas suitable for lighting purposes, without any admixture of English coal being required. Taken in conjunction with other evidence, the high estimation in which it is held by the natives, even those south of the Damoodah, is some guarantee of its superior quality. The coal is specially in request by the Kummars, who come from considerable distances to carry it away, preferring it to the more accessible coal in the vicinity of their forges. It is not quite free from sulphur, and this will be, as is well known, a drawback if it is employed for metallurgical purposes in the form of coke, or as a source of gas. The total thickness of the seam is 15 feet, with a dip of 8° west-south-west. Of this, however, 5 to 6 feet are injured by trap. It exhibits the phenomenon of ball structure, and beautiful examples can be seen illustrative of the manner in which each coating of carbonaceous matter completely envelopes the under one. Lines of lamination are also clearly distinguishable.

Koosoonda seam.

Caking coal.

Probably good gas coal.

Not free from sulphur.

Ball structure.

Analyses of some of the balls show that they contain a remarkably small percentage of ash for Indian coals, not exceeding 2 to 3 per cent. It is usually, though not always, found, that coals with ball structure are superior in quality and more free from inorganic matter than others.

Percentage of ash.

One hundred and eighty to two hundred feet higher in the series is another seam, crossed by a dyke that forms a ridge of some length on both sides of the river, and sends out arms in all directions through the coal as well as the accompanying sandstones, and carbonaceous and sandy shales. For a perfect illustration of the action of trap upon coal this is with, perhaps, the exception of one other, the finest example in the whole field. The coal assumes every variety of form and texture, passing from a light vesicular pumice-like stone through all the intermediate stages until it becomes a hard dense columnar mass. Between the last seam mentioned and the next one above, measuring 1 foot 6 inches, intervene brown micaceo-felspathic shales and shaly sandstones, about 100 feet. Then comes another, having the following section from bottom to top :—

Seam injured by dyke.

Columnar structure.

		Ft.	In.
(a.)	*Coal*		6
(b.)	Parting		2
(c.)	*Coal* (inferior)	2	0
(d.)	Parting		3
(e.)	*Coal* (slaty)		8
	Total of seam ...	3	7
	Total of *coal* ...	3	2

The dip is about 7° south-west by west to west-south-west. None of this coal is worth any thing except the lowest portion (*a*).

The section from this point is not very plainly seen in the river for some way down; then light reddish-grey carbonaceous shales alternating with carbonaceous and light-grey nodular shales containing

pebbles, crop out in the banks dipping at an angle of 10° west-south-west. One small bed of coal, 3 inches thick, occurs.

Koostur coal.

Pieces of trap are next observed in the bed of the river, just above the Koostur seam of 10 feet. The section from this place is —

		Ft. In.
1.	Carbonaceous shale	
2.	*Coal* ..	0 6
3.	Argillo-arenaceous sandstone ..	1 0
4.	*Coal* ..	1 4
5.	Micaceous sandstone	1 6
6.	*Coal* ..	4
7.	Sandstone (about)	6 0 to 7 0
8.	The Koostur seam.	

		Ft. In.
(*a.*)	*Coal*	4 0
(*b.*)	Parting	2
(*c.*)	*Coal*	1 0
(*d.*)	Parting	2
(*e.*)	*Coal*	1 2
(*f.*)	Parting	1
(*g.*)	*Coal*	3 1
	Total of seam (seen) ..	9 8
	Total of *coal* ..	9 2

The bottom part of the Koostur seam (*a.*) is not all seen, as the small coal left by cutting into it hides the flooring. Its total thickness is probably 10 feet. In quality it is only inferior to the Koosoonda coal, the fatty layers being well distributed through it. It has the lines of lamination strongly marked, a common character in most of the specimens of coal of this field. It is also well-jointed, and this will greatly facilitate its working should a colliery be established for the purpose of extracting it.

Quality good.

The beds next occurring are principally made up of carbonaceous shales, and a little way above the junction of the Bulliaree Nullah and Kurree Joor a very fine specimen of a tree was got out of them, showing the change which the outer tissue of the stem had undergone. It was completely metamorphosed into coal. A seam a few inches thick dipping at 10° has been cut into.

Fine specimen of tree.

After this the river runs almost along the strike of the beds, which consist chiefly of white and brownish sandy shales and quartzose sandstones containing pebbles.

Some fine fossil ferns *(Glossopteris)* with the venation of their leaves very distinct occur plentifully here, preserved in a hard flaggy ferruginous shale.

Bhagaband coal.

Three or four worthless seams are met with, between the one a few inches thick, and the next one of any value about 120 feet higher in the series. It is only partially seen in the bed of the nullah, being covered by water. On the left bank, however, where a hollow occurs, it is better exposed, and has been cut into. Its quality is not very good, the pieces of coal which I examined being dense and compact with a preponderance of the dull layers. There is, as usual, a large quantity of iron pyrites. The dip varies between 10° and 12°. The thickness by calculation is 10 feet.

Seam injured by trap.

Some 80 or 90 feet above is another seam altered by trap, making the fourth noticeable case in this section alone. The dip then increases to 12° and 15°, and beds of sandstones chiefly quartzitic, and sandy shales passing into clay shales, make up the section. Pebbles occur throughout.

Kendwadeeh seam.

The last seam is one nearly opposite Kendwadeeh, stretching to Jeetpoor, about 1 foot 6 inches thick, but of which only one foot is good fuel.

The dip now becomes nearly due west, and the Carbonaceous-shale group appears. Below Putteea the Barákars are brought up again by a north-easterly dip, and a poor bed of coal is visible, the last one met with in this river.

A review of the seams shows that at least four of them are of superior quality, and the coal is sufficiently thick to enable them to be

worked with profit. The dips are just high enough to keep them dry, ranging between 8° and 12°. The Koosoonda seam contains coal of the first quality, analysis giving it only 3 to 4 per cent. of ash, but allowing it even 6 per cent., this would still entitle it to a very high place in the category of Indian coals. Some of the best samples of the Kurhurballee field yielded 2·5 to 4·8 per cent., a very near approach in the quantity of inorganic matter to that of the Koosoonda seam.

Koosoonda coal contains 3 to 4 per cent. of ash.

The frequency with which the coal beds are accompanied by trap has been exemplified in this section, and owing to this unfortunate circumstance many seams are rendered to a great extent useless. It does not appear, however, that the trap is continuous with them throughout, so that hope may always be entertained of striking upon other portions of their outcrop free from it.

Seams injured frequently by trap.

To the west of the Kurree, is an area peculiarly abundant in coal seams, exceeding in number any other tract of equivalent size which has hitherto been surveyed in India.

Coal is found east of Footaha in the nullah of that name. The thickness of the seam is 3 feet. The strata in the neighbourhood are more disturbed and assume higher dips than the Barákars usually exhibit. Near Putteea and Kendwadeeh they form a basin in which a small patch of ironstones is preserved, isolated from the main body which crosses the Damoodah River further westward. The Barákars become nearly horizontal near Jurma, and then pass under the upper group near Gunsadeeh. Further north the dips are all low, hardly ever exceeding 12°.

Coal at Footaha.

The rocks composing the district are chiefly thin-bedded felspathic siliceous sandstones and shales with several bands of the yellow slightly

calcareous sandstones so characteristic of the Raniganj Division. The stratigraphy, however, will be best learnt by the sections to follow, which are very complete.

No coal near Gopenathdeeh, &c.

No outcrops of coal occur in the neighbourhood of Gopenathdeeh, Gurboodeeh, or Dhobrajpoor, and none near Bulliaree, except a little seam 2 inches thick to the east, and some indistinct ones that cannot be determined to the south.

Coal north of Koostur.

Running parallel to the dyke north of Koostur is a seam evidently the continuation of the one which exhibits such fine examples of columnar structure in the Chut Kurree. It appears to be about 7 feet thick, but a portion is hid by surface soil so that 10 feet is probably nearer the truth.

Coal south of Dherriajoba.

South of Dherriajoba an excellent outcrop of a seam that occurs below Gurreea is visible in a small hill.

Coal north of Godhur.

North of the tank at Godhur a coal seam shows itself, but not distinctly enough to determine its real thickness. Still further north is a small stream flowing from west to east, and in it is a seam measuring 3 feet. The quality of each is very bad, being nearly all shale.

Besides the above mentioned ones, there are in the locality some burnt seams, a list of which will be found at the end of the economic chapter, where a general summary of the coal seams is given.

Section of the Busraya Nuddee.—In this river we find that the usual succession of beds occurs: at the base grits and coarse sandstones, and then shales, thin-bedded sandstones, and coal. The seams are numerous, and whenever it was practicable the actual amount of coal and shale was measured. It more frequently happened, however, that this could not be done, and therefore in reading through the section, it must be remem-

bered that the thickness of a seam does not necessarily mean the actual amount of coal that it contains.*

Leaving out a few feet of debatable strata, the first bed of undoubted Barákars occurs just at the junction of the Bhoolee and Busraya nullahs.

		Ft.	In.
1.	Carbo-argillaceous shale	2	6
2.	Pinkish coloured micaceous sandstone	7	6
3.	Light blue carbonaceous shale	3	0
4.	Black mud in bank, ? Coal	1	0
5.	Grey sandstone	8	0
6.	Carbonaceous shale	6	0
7.	*Coal.* Dip 15° S. by W.	2	0
8.	Coaly shale	2	6
9.	Carbonaceous shale	1	6
10.	Felspathic siliceous grits	45	0
11.	*Coal.* Seam only partially seen	8	0
12.	Typical Barákar grits passing into coarse felspathic siliceous sandstones	120	0

The section in the river is then hid by sand for a considerable way.

13.	The rocks on the high land which strike for this part of the stream are grits and sandstones. No coal appears. By calculation we get approximately	200	0
14.	Fine-grained argillo-siliceous shales	8	6
15.	*Coal* seam. Dip 12°	11	4

		Ft.	In.
(a.)	*Coal*	1	0
(b.)	Carbonaceous shale ..	4	0
(c.)	*Coal*		8
(d.)	Carbonaceous shale ..		6
(e.)	Red ferruginous shale ..	1	0
(f.)	Carbonaceous shale ..	1	6
(g.)	*Coal* (cut into) ..	2	6
	Total of *coal* ..	4	2

The only coal worth cutting in this seam is the upper portion (*g.*), two feet and a half thick. In the carbonaceous shales numerous specimens of *Vertebraria* and *Glossopteris* occur.

16.	Carbonaceous shale mixed with strings of coal ..	3	0
17.	Sandstones and shales alternating	27	0
18.	Micaceo—slightly felspathic, siliceous, sandstones ..	40	0
19.	Carbo-micaceous shale	20	0
20.	Carbonaceous shale	8	6
21.	*Coal* seam. Dip 10° S. by W.	38	0

The upper two feet are worked, the lower portion is shaly. The whole, however, is obscurely seen.

22.	Alternating thin-bedded sandstones and shales ..	130	0
23.	*Coal* seam	18	0

This is opposite Gurreea.

Amount carried forward .. 711 4

* Water flowing over the beds often imparts to them a deceptive appearance. Carbonaceous shale, and especially coaly shale when wet, resemble coal so closely that it is impossible to detect the difference by a cursory examination only.

		Ft.	In.
	Amount brought forward ...	711	4
24.	Carbo-arenaceous shales	20	0
25.	*Coal* (good)	1	1
26.	Carbo-arenaceous shales	9	0
27.	*Coal* seam. Dip 10°	1	0

	Ft.	In.
Coal	0	2
Shale	0	1
Coal	0	9
Total of *coal* ..	0	11

This occurs at the corner of the river.

		Ft.	In.
28.	Reddish brown arenaceous shale	1	6
29.	Carbonaceous shale	0	10

The river now runs nearly along the strike of the beds.

		Ft.	In.
30.	Sandstones and shales, carbonaceous	15	0
31.	Coaly shale, in places mere ordinary carbonaceous shale ...	1	0
32.	Shales more or less carbonaceous	27	0
33.	*Coal*, seam two to three feet	3	0

Village of Ekra opposite.

		Ft.	In.
34.	Intermediate beds to the bend of the stream not seen clearly for 153 yards horizontal. The calculated thickness will be	80	0
35.	From the bend, they are better exposed, consisting mainly of sandstones; calculated thickness	150	0
36.	Carbonaceous shales	11	0
37.	Sandstones...	5	0
38.	Carbonaceous shales	1	8
39.	*Coal* seam. Dip 15°	'8	6

	Ft.	In.
Coal	3	0
Parting		4
Coal ...	5	2
Total of *coal* ...	8	2

This seam is exposed twice along the banks of the river. The quality of the coal is above the average, and there is every probability of its improving when sunk into. Ball structure is seen in it.

		Ft.	In.
40.	Light brown micaceous siliceous shales, and sandy shales ...	117	0

The beds form here an anticlinal, due to squeezing. Others in the locality have been similarly affected, accompanied by a change in strike.

		Ft.	In.
41.	*Coal* seam. Dip 6° S. E. to S. E. by S.	21	0
42.	Sandstone	3	0
43.	*Coal* seam. Dip 4°	22	0

This seam stretches south of Bansdeopoor, and is well exposed in the small streamlet flowing into the Busraya nullah.

		Ft.	In.
44.	Shales	48	0
45.	Shales affected by trap	12	0
46.	Intermediate beds from the above trap to the corner of the river, (where it turns to the west)	60	0
47.	Flaggy micaceous and argillaceous shales	31	0

Another change in strike now occurs. The dip becoming W. S. W. 10° exactly. At the end of the reach it becomes a little more southerly (S. W.), and a coal seam is seen to which succeed,

Amount carried forward ... 1,360 11

		Ft.	In.
	Amount brought forward ..	1,360	11
48.	A long series of flaggy micaceous and argillo-siliceous shales with a few bands of calcareous sandstones, weathering with a yellow exterior. Pebbles occur in many of the shales	240	0
49.	*Coal*	1	0

Further down the river this becomes carbonaceous shale only.

50.	Coaly shale	0	4
51.	Reddish brown arenaceous sandstone	3	4
52.	Carbonaceous shale	2	6
53.	Argillaceous sandstone	7	0
54.	*Coal* seam	4	6

	Ft.	In.
Coal	2	0
Carb. shale ..		9
Coal	1	9
Total of *coal* ..	3	9

The quality of this coal is very good. In the reach of the river, where it occurs, the seam is capped by 7 feet of the succeeding white felspathic sandstone.

55.	White micaceous felspathic siliceous sandstone slightly calcareous, and shales	34	0
56.	*Coal*	3	8
57.	Arenaceous sandstone, seven to eight feet	8	0
58.	*Coal* seam. Dip 5.°	1	9

	Ft.	In.
Coal	0	8
Ironstone parting	0	4
Coal	0	9
Total of *coal* ..	1	5

59.	Thin-bedded areno-argillaceous sandstones, all slightly carbonaceous. Dip 8.°	55	0
	Dyke striking west-north-west.		
60.	Intermediate beds dipping at a higher angle than the average (about)	20	0
	Dyke striking west-north-west.		

These two dykes are probably branches of the same one.

61.	False-bedded sandstones, felspathic and siliceous, containing pebbles	42	0
62.	*Coal* seam, exposed in the reach	5	0

		Ft.	In.
(a.)	*Coal* ..	2	6
(b.)	Shaly parting	0	8
(c.)	*Coal* ..	1	10
	Total of *coal* ..	4	4

The whole of the coal (*a.*) is not seen in this reach, but lower down the river, where it appears again. At the mouth of the Lewabad nuddee it is injured by trap.

	Ft.	In.
Amount carried forward ..	1,789	0

			Ft.	In.
	Amount brought forward	...	1,789	0
63.	False-bedded micaceous sandstone	... ...	18	6
64.	Slightly calcareous sandstone ...	... ...	1	9
65.	False-bedded micaceo-felspathic sandstones containing pebbles	... ...	20	6
66.	*Coal* seam, eleven feet one inch to..	... ...	11	3

Coal (superior)	4	2
Carbo-argillaceous shales ...	4	9
Coal	2	2 to 2 4
Total of *coal*	6	6

This seam is seen three times.

67.	Carbonaceous shales and sandstones alternating	...	106	0
	Dip 8°			
68.	Very micaceous white siliceo-argillaceous sandstone	...	8	4
69.	*Coal* seam	...	1	5

Coal	0	3
Carbonaceous shale	0	7
Coal	0	7
Total of *coal* ...	0	10

Total	...	1,956	9

This seam is seen in the adjoining stream, the Busjooreea. There, however, it consists entirely of carbonaceous shale.

From this point the Section is carried on in the Busjooreea nullah: No. 123, (page 270,) corresponding to No. 69.

Making, as usual, a summary of the seams, we find that within a distance of two miles and three quarters the average dip being 10°, we have eighteen seams with an aggregate thickness of 162′ 0 or $\frac{1}{13}$th of the whole mass of strata, a fact which fully tends to bear out the assertion that the area west of the Kurree Joor is one peculiarly rich in coal seams.

The quality of the coal is, on the whole, rather below the average. The Ekra seam (No. 39), the Bansdeopoor (No. 43), and Nos. 54 and 62, are the principal seams, and superior to any of the rest. The Bansdeopoor one is most cut into, and as its coal exhibits ball-structure to a strong extent, it will most probably be found good throughout. A small dyke about 3 inches broad crosses it in one part.

Papery structure of seams.

Several of the minor seams possess a papery structure, and they split easily into very thin laminæ. It is not peculiar to them, however, being also developed in carbonaceous shale. It appears to be due to the alternate deposition of very fine layers of argillo-carbonaceous mud and of coal. In none of them were there any casts of crustacea or other forms of life.

Slightly calcareous sandstones are more frequent than would appear from the section. They generally present a bluish tint when fractured, but externally they weather yellow. In the Kuttree and Khodo nuddees to the west, they are well developed.

Implements.

Pebbles are just as plentiful in these rocks as in other parts of the field, and along the banks of the river they occur in several heaps. Amongst some of these my colleague Mr. Ball discovered some stone implements, which were amongst the first found in Bengal. I obtained one myself in the Bokaroh field, but I brought it home rather through curiosity than through any conviction that it was the result of manufacture. Their age is difficult to determine, as they were all found on the surface. Most of them have an extremely recent appearance, but some of them, which are stained, might pass off as of ancient origin.*

Many of the thinner sandstones in the above section are false-bedded, a character not common in the Barákar group, and when occurring, confined chiefly to the upper portion of it, and to the grits and pebble beds at the base.

Coal at Lewabad.

The continuations of the seams in the Busraya are not distinctly seen at the surface in the tract between it and the Busjooreea with the exception of one west of Lewabad. This is not cut into and the quality appears to be bad.

* The pebbles split with great facility, and it is possible that the little "goorkeea" or cowherd boys finding a heap of stones amuse themselves by knocking them together, and may so produce some of those very rude flakes which have been attributed to a long bye-gone race of beings.

Section of the Busjooreea.—This section is not so well exposed as the foregoing one. In many places the rocks are covered up by sand, which is shifted about during each rainy season, so that it often happens that beds of coal visible one year are hidden the year after. This of course is more usually the case in large rivers, where the quantities of sand are greater, and the transporting power of the water stronger. In the Damoodah it is especially so.

Section in places imperfect.

The bottom beds exhibit a perfect parallelism or conformity with those of the Talchirs. The section is approximately the following :—

		Ft.	In.
1.	Slightly carbonaceous, argillo-siliceous shales	3	0
2.	Compact siliceous sandstone	3	0
3.	Carbo-siliceous shales	2	0
4.	Coaly shale		6
5.	Micaceous siliceous sandstone with carbonaceous markings ..		4
6.	Argillo-siliceous carbonaceous shale	2	0
7.	Coarse granular sand stone, and light blue argillo-carbonaceous shales	38	0
8.	*Coal*	2	0
9.	Carbonaceous shale	2	6
10.	Sandstone	1	2
11.	Carbonaceous shale with lime in it	3	0
12.	Purplish weather-stained and granular micaceous sandstone ..	12	0
13.	Clay shale	1	0
14.	*Coal* seam	1	2
	Coal .. .. 0 5 } Shaly parting .. 0 7 } Dip 15° *Coal* .. .. 0 2 }		
15.	Coarse grained sandstone, some of it passing into grit	30	0
	The surface is covered with little rounded knobs, about ¼th of an inch in diameter, produced by weathering.		
16.	*Coal* seam	38	0
	This is traceable to the north of Chundore.		
17.	Varying sandstones and grits, (not distinctly seen)	156	9
18.	Bluish black slightly carbonaceous and siliceous shales breaking with a conchoidal fracture	4	0
19.	*Coal.* Dip 15° and 14°	5	2
20.	Coaly and carbonaceous shale	33	0
21.	Grits	25	0
22.	Sandy carbonaceous shale	2	0
23.	*Coal*	1	0
24.	Nothing is seen in the river for a hundred and sixty yards. Calculated thickness will be	120	0
25.	Sandstone containing quartz pebbles	2	0
26.	Carbonaceous shale with *coal* 8 inches thick in the middle ..	7	0
27.	*Coal.* Dip 10°	1	0
28.	Carbonaceous shale..	1	6
	Amount carried forward ..	497	4

		Ft.	In.
	Amount brought forward ..	497	4
	The river section is again imperfect for two hundred and seventeen yards; calculated thickness	114	0
29.	Micaceous slightly carbonaceous shale with a ferruginous band of 1 foot at the top	8	6
30.	*Coal* of which 5 inches are exposed and the rest hidden ..		
31.	Only sand for ninety yards. Calculated thickness	45	0
32.	Sandstones	8	0
33.	Sand for fifty yards. Calculated thickness	26	0
34.	Light-grey argillo-micaceous sandy shales and sandstones ..	50	0
35.	Slightly carbonaceous micaceo-siliceous shales	9	0
36.	Coaly shale	2	0
37.	Sandstones and carbonaceous shales, not very thick (about) ..	20	0
38.	Shale	0	4
39.	*Coal.* Dip 10° S. S. W.	1	8
40.	Shale	0	2
41.	Compact micaceo-siliceous sandstones containing pebbles ..	76	0
42.	Slightly carbonaceous siliceous shales	4	9
43.	Sand covering up the beds for a distance of 13 feet	1	8
	The river bed is here holed in two places, and some coal has been extracted. Sand covers every thing up.		
44.	*Coal* seam, obscurely seen	12	0
45.	Thin-bedded arenaceous sandstones and flaggy carbo-arenaceous shales	15	0
46.	Reddish ferrugino-micaceous sandstone	3	0
47.	*Coal* of variable quality	12	5
	The river then bends to the west.		
48.	Carbo-argillaceous shales, thin bands of yellow slightly calcareous sandstones, and arenaceous sandstones, dip 15°	25	0
49.	Slightly concretionary carbo-micaceo-arenaceous shales and fine grained grey siliceous sandstones, dip 20°	34	0
50.	For fifty-seven yards no section in the bed of the river is seen. It is underlayed by coal, as I saw some people taking it away. On the right hand side, a short distance inland, several seams are exposed, evidently the continuation of those that are concealed in the river, as they strike directly for the spot.		

Their section is, from the base—

	Ft.	In.
Coal, dip 12°	10	0
Sandstones and shales	15	6
Coal, dip 20°: some crushing takes place	7	4
Sandstone, dip 18°	15	0
Coal	17	0
Sandy shale	5	0
Coal, dip 20°	22	0
Total thickness ..	91	10

Ninety-one feet is a greater thickness than these beds present in the Busjooreea; that is, supposing the dips are the same, it is quite possible however that the thickness is apparently exaggerated by a small amount of faulting. The coal is extensively used, and the 22 feet seam surpasses the rest in quality. A considerable quantity of iron occurs at the surface in a pisolitic form.

Amount carried forward ..	965 10

		Ft.	In.
	Amount brought forward ...	965	10
51.	Thin-bedded sandstones and carbonaceous shales, dip 20° ...	29	0
52.	Slightly calacreous sandstone	2	0
53.	Mainly carbo-arenaceous shales, and thin-bedded sandstones of the same composition, dip 24°	60	0
54.	Similar beds, with some free from carbon	120	0
	In these rocks the dip varies from 28° to 36° to 30°.		
55.	*Coal*, dip 31°	5	6
56.	Micaceo-arenaceous sandstone thinly bedded, dip 30°	145	0
57.	*Coal*, dip S. by W....	2	4
	The river here turns south.		
58.	Very fine grained siliceous sandstone and carbo-argillaceous shales, dip 22°	40	0
59.	Slightly calcareous sandstone (about)	2	0
60.	Micaceo-arenaceous shales tinged by carbon, dip 20°	27	0
61.	*Coal*	0	7
62.	Yellow slightly calcareous sandstone	1	6
63.	Argillo-arenaceous sandstone slightly carbonaceous	5	0
64.	Carbonaceous shale...	0	4
65.	*Coal*	0	2
66.	Very fine grained siliceous sandstone tinged, as they usually are, by carbon	15	0
67.	Yellow slightly calcareous sandstone, dip 18°	0	8
68.	Slightly carbo-arenaceous shales	20	0
69.	Yellow slightly calcareous sandstone	3	0
70.	Sandstone and carbonaceous shale	17	0
71.	*Coal* seam	1	5

	Ft.	In.
Coal	0	8
Carb. shale	0	7
Coal	0	2
Total of *coal* ...	0	10

		Ft.	In.
72.	Shale	0	11
73.	Highly micaceous siliceo-argillaceous sandstones containing a small proportion of carbon; false-bedded and yellowish from the presence of iron	20	0
74.	Arenaceous shales, dip 25°	22	0
	All these shales, whatever their composition, are more or less impregnated by carbonaceous matter.		
75.	Carbonaceous shales	4	2
76.	*Coal* seam, dip 21°...	12	6
77.	Arenaceous sandstones, dip 20°	30	0
78.	*Coal* seam	2	9

	Ft.	In.
Coal (bad)	0	9
Parting	0	3
Coal	1	6
Total of *coal* ..	2	3

Then comes a quaquaversal dip. The beds on the left bank dip S. E. On the right bank the two seams 76 and 78 are seen again; the strike in each changed. About 50 yards down the river the next coal in ascending order dips in the normal direction. A small fault occurs, so that its thickness cannot be accurately determined.

Amount carried forward ... 1,555 8

		Ft.	In.
	Amount brought forward ...	1,555	8

The beds succeeding to the faulted coal are—

		Ft.	In.
79.	Thin-bedded argillo-arenaceous sandstones, all more or less coloured by carbon, dip 15°	20	0
80.	Highly micaceous felspathic and siliceous sandstone ...	1	
81.	Carbo-argillaceous shales, with two or three bands of yellow calcareous sandstone	18	6
82.	*Coal* seam, dip 10°	9	10

	Ft.	In.
Coal	1	6
Carb. shale	0	8
Coal	7	8
Total of *coal* ...	9	2

This seam is faulted with a downthrow of five feet. Above it come shales and white sandstones.

This fault has had a downthrow on the south, with a maximum amount in an easterly direction; this of course alters the dip of the portion thrown, and accounts for the south-easterly direction of the inclination of the seam.

		Ft.	In.
83.	Shales and white sandstones, a few feet		
84.	*Coal* seam	32	0

This coal is much cut into, and appears to be of superior quality. It occurs opposite Jugta.

		Ft.	In.
85.	Carbonaceous shales containing a few ironstones	38	0
86.	Reddish carbonaceous micaceous shales (rippled)	7	0
87.	False-bedded sandstones, dip 16° (about)	40	0
88.	*Coal* seam	10	0
89.	Ferruginous carbonaceous shale	1	0
90.	*Coal* seam	8	0
91.	Flaggy shales and sandstones containing carbon, dip 12° ...	56	0
92.	Slightly calcareous sandstone	1	6
93.	Flaggy shales and sandstones	36	0
94.	*Coal* seam, inferior	2	0
95.	False-bedded sandstones	30	0
96.	Micaceo-argillaceous sandstone	4	0
97.	Carbonaceous shale...	1	4
98.	Concretionary argillaceous shale	2	6
99.	Coaly shale	0	8
100.	Concretionary argillaceous shale	2	4
101.	Arenaceous sandstone, thin-bedded	0	7
102.	*Coal* (good)	0	6
103.	Micaceo-arenaceous sandstone	3	6
104.	Carbonaceous shale...	1	3
105.	*Coal* seam with carbonaceous shale in the middle, 1 inch ...	0	4
106.	Micaceo-argillaceous shale, concretionary	4	3
107.	Coaly shale	0	5
108.	Micaceo-arenaceous sandstone	6	4
109.	Carbonaceous shale...	0	3
110.	*Coal*	0	4
111.	Flaggy shales and sandstone	27	0
112.	Concretionary shales	6	9
113.	Coaly shale	1	0
	Amount carried forward ...	1,930	6

		Ft.	In.
	Amount brought forward ...	1,930	6
	Dyke N. W. by W.		
114.	Calcareous sandstone, rather indefinite	6	0
115.	Concretionary argillaceous shales and brown arenaceous sandstones	34	6
116.	False bedded felspathic siliceous sandstone containing impressions of *vertebraria*	8	6
117.	*Coal*, extensively cut into	10	6
	One foot of parting occurs in the middle, and with the exception of the top one foot and a half, all is good coal. Assay gave 7 to 10 per cent. of ash.		
118.	Argillo-arenaceous shale	12	9
119.	*Coal* (inferior)	3	0
120.	Alternations of concretionary shales and sandstones; several of the latter false bedded	35	0
121.	Slightly calcareous sandstone	1	6
122.	Shales and sandstones	45	0
	Included in this is a bed of carb. shale 1′ 6″; corresponding to No. 69 of the Busraya Nullah.		
123.	*Coal*, a yard or so above the junction of the two streams of Busraya and Busjooreea	1	1
124.	Light grey micaceo-argillaceous shales	150	0
125.	*Coal* seen first on the left bank, then on the right	0	6
	The river here runs along the strike of the beds.		
126.	Micaceous argillo-siliceous shales, carbonaceous shales, and purplish micaceous shales	140	0
127.	Carbonaceous shales, and three seams of ironstone	4	6
128.	Light grey micaceo-argillaceous shales	8	0
129.	*Coal*	0	4
130.	Micaceous argillo-siliceous shales	4	0
131.	Carbonaceous or coaly shale	0	2
132.	Siliceo-micaceous argillaceous ironstained beds	4	0
133.	*Coal* seam	1	2

	Ft.	In.
Coal	0	4
Carbonaceous shale ...	0	8
Coal	0	2
Total of seam	1	2
Total of *coal*	0	6

		Ft.	In.
134.	Slightly micaceous felspathic siliceous shaly sandstones containing pebbles and boulders; purplish micaceous shales	7	0
135.	*Coal* injured by trap		
	Dip variable, faulty ground.		
136.	Carbonaceous shales. Dip 15°...	25	9
137.	Chiefly sandstones containing pebbles; and sandy shale dipping at angles of 15°, 20°, and 30°	117	0
138.	Black carbonaceous shales, and argillo-siliceous shales	34	0
139.	Yellow slightly calcareous sandstone, and carbo-argillaceous shales	60	0
140.	Coaly shale containing *vertebraria*	2	0
141.	Intermediate beds (about)	60	0
142	*Coal*	0	4
143.	Intermediate beds (about)	180	0
144.	Underclay and *coal*. Dip 14° S. W. by S.		11
	This coal occurs a little way above the village of Dook-hiddeeh, and is the highest seam of the series.		
	Total ...	2,888	1

Just north of the bridge, over which the Ranchee Road is carried, some ironstones crop out. It is only, however, at the confluence of the Busjooreea and Kuttree that they become properly developed.

The total thickness of the Barákars is seen in the above section. Allowing for the beds higher in the series than the last coal seam mentioned, they may safely be put down at 3,300 feet, a much grander development than they have in other coal-fields yet examined.

Comparing this with the Busraya section, it can be at once seen that there is great irregularity between them, in the number of seams that they each contain, and in the proportionate thickness these bear to the other rocks. In the present instance they form about $\frac{1}{9}$ of the whole.* This comparison gives no idea as to the actual amount of coal in either, which may be identical or nearly so, but proves the irregularity, which has been so often adverted to, of the seams of this series.

Quality low.

The quality of the coal in general is below the average, but as the opportunities for judging were scarce, owing to so few of the seams being cut into, fuel of a superior character may exist without having been discovered. Nos. 50, 84, and 117, contain good coal, especially the latter.

Coincidence of the strike of seams and course of river.

The frequent coincidence of the course of the river with the outcrops of seams, is more strikingly displayed in this than in most other sections. Examples of it are to be seen in every stream, but it usually occurs only when the seam is capped by a hard rock. The water, during the excavation of a river channel, must naturally have a tendency to eat along the face of the coal or shale, owing to the greater degree of softness of this rock as compared with the bed capping it, (unless the stream

* This comparison is made from the junction of the two rivers to the points where they pass from the Barákar into the Talchir rocks.

meets with a joint or crack through which to pass,) and thus produces the coincidence referred to.

Coal at Chundore.

On the high land to the west of the Busjooreea, in addition to the seam previously referred to as stretching to the north of Chundore, another is seen immediately to the south, dipping at its outcrop with an angle of not more than 5° to 6°. It may turn out to be entirely coaly-shale, but at the surface it breaks up into blunt-edged squarish pieces, which is always a good indication of coal. Following this seam in an easterly direction, a smaller one, about 3 feet thick, occurs above it. These two are not shown in the Busjooreea section, their strike being direct for a portion of the river, which is covered by sand.

Burnt seams occur as usual, and will be found enumerated in the list at the end of this report.

The grits and hard sandstones at the base of the series form a small scarp north of Chundore, and low ridges near Kantapaharee. Between the Busraya and Busjooreea the elevations are not so prominent as usual.

Section of the Kummar-Joor.—The next section is in another tributary of the Kuttree, known as the Kummar-Joor.

The first coal occurs at its junction with the Nugree nullah close to Muttialla. It is nearly all shale, with a thickness of about 7 feet. Then succeeds white siliceous sandstone, and coarse felspathic slightly carbonaceous shale, above which comes a bed of inferior coal 6 feet 2 inches, and carbonaceous shale 10 feet 6 inches. Between this and the seams north of, and opposite Ramkinnalee grits and sandstones now and again crop out in the banks of the stream, presenting all the characteristics of the group.

The section near Ramkinnalee, commencing with the lowest seam, is—

		Ft.	In.
1.	*Coal* seam imperfectly seen.		
2.	Sandstone (a few feet).		
3.	Dark bed (ditto).		
4.	Ferruginous flaggy shale	7	3
5.	Carbonaceous shale	4	0
6.	Light blue argillo-carbonaceous shales, and also micaceo-siliceous shales	4	0
7.	Coaly shale	6	4
8.	Ironstone	0	4
9.	*Coal*	6	1
10.	Carbonaceous shale	4	4
11.	Micaceo-siliceous shale..	1	0
12.	*Coal*	5	4
13.	Shale	3	0
14.	Fine grained light brown siliceous sandstones	8	0
15.	*Coal* (inferior quality)	4	6
16.	Shales, fine grained and siliceous (about)	10	0
17.	*Coal*, very much decomposed and impregnated by iron (about) ..	8	0
		72	2

Dip 20°, direction S. S. E.

The direction of dip in this section is in striking contrast to that which prevailed in the Busjooreea. It will be observed, however, on looking at the map, that it corresponds with an alteration in the contour of the field, a fact of very common occurrence. There may be a small fault coursing nearly parallel with the Kummar-Joor that causes this change, but the whole surface is so covered by alluvium that the proofs of its existence are not sufficient to justify its assumption.

Coal west of Kantapahara.

From where the section ended to Kantapahara no coal is seen to crop out in the river, the whole succession of strata being greatly obscured. Immediately west of it an 8-inch seam occurs with a dip of 9°. Then succeed carbonaceous shales with bands of poor ironstone, and an indistinct bed of coal. Sandstones make up the section to the mouth of the Kuttree.

Section in Kuttree Nuddee.—This river first comes into the field opposite the town of Kutras, and the scenery in the neighbourhood of the temples is very picturesque, the banks being steep and well-wooded. The bottom beds of the Barákars are coarse grained rough-looking

siliceous shales, with a small percentage of carbonaceous matter, giving them a greyish-blue colour, above which come—

		Ft.	In.
1.	Siliceo-carbonaceous shales	2	0
2.	Light grey arenaceous shales	3	0
3.	Coaly shale	7	0
4.	*Coal* of inferior quality, dipping at an angle of 14° to the south ..	2	0
5.	Sandstones passing into grits of the ordinary type	20	0

The section is then broken, and no beds are seen for 430 yards, until a large seam of coal crops out along the margin of the river north of Salanpoor. The whole of it, with the exception of the lower portion, measuring 4 feet 6 inches, and which is covered by water, can be closely examined. The coal is a hard slaty rock, containing a large quantity of iron, which discolors the ash. The amount of inorganic matter is considerable, but this appears to be no drawback in the eyes of the natives, and they use the coal for every purpose in which wood was formerly employed.

6. The section is—

		Ft.	In.	Ft.	In.
a.	Part hidden by water	4	6	22	2
b.	*Coal*	2	0		
c.	Parting	0	8		
d.	*Coal*	3	0		
e.	Parting (siliceo-ferruginous shale and black slate) ..	1	6		
f.	*Coal* (cut into)	1	0		
g.	Parting	0	6		
h.	*Coal* (cut)	4	0		
i.	Parting	1	0		
j.	*Coal*, impure (cut)	4	0		
	Amount of *coal* ..	14	0		

		Ft.	In.
7.	Carbonaceous shale	2	0
8.	Micaceo-siliceous shales	2	0
9.	Intermediate beds*	30	0
10.	Coaly shale, thin		
11.	Intermediate beds	68	0
12.	Dark looking bed, probably carbonaceous shale		
13.	Intermediate beds	80	0

		Ft.	In.	Ft.	In.
14. *a.*	*Coal*	5	4	7	11
b.	Black carbonaceous shale, ferruginous towards the base..	1	1		
c.	*Coal* (inferior)	1	6		
	Amount of *coal* ..	6	10		

		Ft.	In.
15.	Shale	0	8
16.	Sandstones	24	0
	Dyke, about 15 inches wide, is seen on the left hand side of the river; direction W. by S.		
17.	Sandstones, alternating with carbonaceous shales	70	9
18.	Coaly shale	1	0
19.	Ironstone shale	0	2
20.	*Coal*	2	0
21.	Shaly sandstones with plant remains	34	0

* These intermediate beds are not distinctly seen, and therefore their lithological characters are not alluded to.

No.		Ft.	In.	Ft.	In.
22.	a. *Coal*	4	0	16	2
	b. Ironstone parting	1	0		
	c. *Coal*	5	0		
	d. Ferruginous clay shale	0	6		
	e. *Coal*	1	0		
	f. Clay shale	0	4		
	g. *Coal*	4	4		
	Amount of *coal* ...	14	4		

This coal is by no means of good quality. It ignites feebly, and leaves a large quantity of ash. The dip is 10.°

No.		Ft.	In.
23.	Sandstones and shales alternating	105	0

At this spot the northern mouth of the Kummar-Joor falls into the Kuttree.

No.		Ft.	In.
24.	Sandstones containing minute crystals of garnets	70	0
25.	*Coal*	0	4
26.	Carbonaceous shale	0	6
27.	Light blue siliceous shale	0	6
28.	Tesselated ferruginous shale	1	0
29.	Argillo-carbonaceous shale	2	0
30.	*Coal* (inferior)	2	8
31.	An alternating series of sandstones and shales not distinctly visible	142	0

Here the southern mouth of the Kummar-Joor falls into the Kuttree.

No.		Ft.	In.	Ft.	In.
32.	False-bedded sandstones containing pebbles and boulders, succeeded by purplish ferrugino-siliceous shales			34	0
33.	*Coal*			2	0
34.	Felspathic siliceous sandstones (about)			30	0
35.	Hard siliceo-carbonaceous shale with concretionary structure ...			3	0
36.	a. *Coal*		3	1	7
	b. Siliceous shale		2		
	c. *Coal*		2		
	d. Carbonaceous shale		4		
	e. Siliceous shale		4		
	f. *Coal*		2		
	g. Slightly carbonaceous siliceous sandstone		1		
	h. *Coal*		1		
37.	Conglomerate band			0	0
38.	Slightly carbonaceous fine grained siliceous shales			6	0
39.	Massive sandstones, imperfectly seen			85	0
40.	*Coal* seam, concealed by the sand in the river, and only exposed in those places where it has been cut into. The holings made in the shallow parts of the bed of the stream extend for a horizontal distance of 123 yards, thus giving the seam, with a dip of 10°, a total thickness of 64 ft. 0 in. A parting of sandstone divides it into two portions; the more northerly contains a bright lustrous coal, which, however, yields on assay a rather larger percentage of ash than it would be supposed on mere inspection to possess, being as much as 22 per cent. The portion of the seam south of the sandstone parting cannot be less than 30 feet; it forms a conspicuous ridge north of Ungarputra, and can be traced nearly to Modeedeeh, after which it becomes hid in the cultivated ground ...			64	0
41.	Shaly sandstones and shales			130	0
42.	*Coal*				10
43.	Splintery argillaceous shales, and white fine-grained felspathic siliceous sandstones false bedded			16	0
44.	Blue carbonaceous shale with concretionary structure			3	0

No.	Bed	Ft. In.	Ft. In.
45.*a.*	*Coal*	8	
b.	Ironstone parting	2	
c.	*Coal*	3 0	
d.	Carbonaceous shale	2	6
e.	*Coal*	1 6	
f.	Carbonaceous shale	3 to 4	
g.	*Coal*	4	
	Amount of *coal* ..	5 6	
46.	Fine grained siliceo-micaceous sandstone with streaks of carbonaceous matter		4 0
47.	Carbonaceous shale with numerous plants		1 10
48. *a.*	*Coal*	6 0	
b.	Argillaceous parting	1	6 7
c.	*Coal*	6	
	Amount of *coal* ..	6 6	

The above two seams afford peculiar facilities for being worked, on account of the absence of thick partings, and the moderate angle at which they dip, not more than 10°. The quality of the coal is fair.

No.	Bed	Ft. In.	Ft. In.
49.	Alternations of carbo-argillaceous shales, and fine grained iron-stained sandstones		56 0
50.	*Coal*, exhibiting cleet on a minor scale		0 5
51.	Carbonaceous and arenaceous shales		5 9
52.*a.*	*Coal* (not very plainly seen)	1 9	
b.	Carbonaceous slaty shale	2	2 8
c.	*Coal*, stony	9	
	Amount of *coal* ..	2 6	
53.	Grey argillaceous shale		0 3
54.	Shale with strings of *coal*		1 3
55.	Argillaceous shale		1 0

Slightly calcareous sandstones now become prominent. They usually stand well out from the other beds, and catch the eye as much by their peculiar weathering, as by their yellow colour.

No.	Bed	Ft. In.
56.	Grey, felspathic and micaceo-siliceous sandstones, alternating with carbonaceous shales, and slightly calcareous sandstones ..	79 0
57.	*Coal*	0 3
58.	Carbonaceous shale	3
59.	Dark grey argillaceous shales tinged with carbon along portions of their outcrop	4 6
60.	*Coal*	5
61.	False-bedded, highly micaceous felspathic sandstones containing pebbles	5 0
62.	Carbonaceous shales	3 6
63.	Beds mainly composed of very fine grained micaceo-arenaceous shales, with numerous bands of slightly calcareous yellow sandstones, dipping from 8° to 10°	75 0
64.	Outcrop of *coal* imperfectly seen on the right hand bank ..	
65.	False-bedded highly micaceous sandstones containing pebbles ..	30 0
66.	*Coal* seam of average quality: dip 8°	5 9

The village of Kummarjoree opposite.

No.	Bed	Ft. In.
67.	Sandy micaceous shales	8 0
68.	Micaceous sandstone	4 0
69.	Carbonaceous shale	1 6

			Ft.	In.
70.	False-bedded sandstones, containing boulders of mica-schist, quartzite, and pure quartz (about)		20	0
71.	Carbonaceous shale, and underclay		2	0

		Ft. In.			
72. a.	*Coal*	1 2	Dip 15°	3	4
b.	Red clay-shale	0 2			
c.	*Coal*	2 0			
	Amount of *coal* ...	3 2			

		Ft.	In.
73.	Fine grained siliceous sandstone with vegetable markings ...	1	10
74.	Light grey argillaceous and carbonaceous shales	6	0
75.	*Coal.* Dip 17°	1	0
76.	Carbonaceous shale	0	10
77.	Arenaceous and carbonaceous shales	40	0
78.	Yellow slightly calcareous sandstone	4	6
79.	Arenaceous shales containing boulders. Dip 20°	56	0
80.	Carbonaceous shale and coal	2	0
81.	Brown, thinly laminated, fine grained arenaceous shale ...	5	6

The entire series of beds have hitherto succeeded each other without exhibiting any sign of having undergone peculiar contortion or disturbance. A gradual increase in dip takes place from No. 67, until eventually they rapidly become vertical. Against these highly inclined strata nearly horizontal beds succeed, differing, however, in no respect in lithological composition. It is evident that a line of fault crosses the river near No. 81, accompanied also by another at right angles to it, cutting off the beds to the east, of which ample evidence is afforded by the utter difference in the section of the Kuttree, and one of the small feeders that joins it opposite to Rampoor.

The first of the nearly horizontal beds is—

		Ft.	In.
a.	Red micaceous sandstone	2	0
b.	Grey siliceo-argillaceous shale	1	6
c.	Black carbonaceous shale and ironstone	1	6
d.	Grey and brown sandy shales	3	0
e.	Argillaceous and sandy shales with mica, containing two little bands of coal about 2 inches and 1½ inches respectively	3	6
f.	Sandstone and shale with boulders	4	5

Here another fault occurs with a small downthrow to the south. A little distance down the river the beds dip at their usual angles of 10.°

		Ft.	In.
g.	Arenaceous shales	6	0
h.	Brown sandy shales, with boulders	9	0
i.	White sandy micaceous shales	2	6
j.	*Coal* (not distinct) about	1	6
k.	Grey argillaceous shale	1	4
l.	Micaceous greyish brown shales	2	2
m.	*Coal,* papery		8
n.	Argillaceous shale		4
o.	Micaceous sandstones containing pebbles (about)	5	0
p.	Slightly carbo-micaceous shales	1	0
q.	Sandstone containing boulders	3	0
r.	Carbonaceous shale, and ferruginous sandy shale	3	0
s.	False bedded sandstone containing boulders	3	6
t.	Sandstone and micaceous sandy shale with pebbles	5	0

Beds similar to the above form the section for the next 90 yards, where the strata once more exhibit signs of disturbance. The

Ft. In.

river runs nearly east and west, and the village of Rampoor indicates the spot. A coal seam crops out in the reach.

Coal (obscurely seen)—

	In.
Grey argillaceous shales	5
Black carbonaceous shales	3
Coal	2¼

The dip is very various here, and the same beds have a southerly lie, with an east and west roll. Above the seam first detailed come grey and brown sandy shales, a conglomerate band, then grey argillaceous shales, with a small quantity of carbonaceous matter in some instances, and another seam measuring 1 foot 7 inches. Towards the east end of the reach there is great disturbance, and a hard siliceous sandstone standing up in the bed of the stream forms a prominent feature.

The succeeding strata are—

			Ft. In.
1*a*.	Grey argillo-micaceous shales		4 0
2*a*.	Purplish micaceous shales, containing large boulders and white false bedded shales with red spots		8 6
3*a*.	Grey micaceous shales		1 0
4*a*.	Grey argillaceous shales		6
5*a*.	*Coal* and coaly shale		6
6*a*.	Grey arenaceous shales, with boulders		6 0
7*a*.	Argillo-micaceous shales, with poor sandy ironstones		3 6
8*a*.	Ferrugino-micaceous shales		3 6
9*a*.	Dark siliceo-carbonaceous shale		1 9
10*a*.	Brown sandy shale		1 6
11*a*.	Carbonaceous shale and ironstone		5 3
12*a*.	Brown and bluish sandy shales		5 0
	The dip is high at this spot.		
13*a*.	Micaceous sandstone		6 0
14*a*.	Carbonaceous shale and ironstone		3 6
15*a*.	Brown micaceous sandstone		9 0
16*a*.	Siliceo-argillaceous shales		2 6
17*a*.	Coaly shale and ironstone		4
18*a*.	Sandy shale with carbonaceous matter		4 0
19*a*.	*Coal*	0 7	
	Coaly shale	0 5	1 2
	Coal	0 2	
20*a*.	Carbonaceous shale		11
21*a*.	Brown siliceous sandstone, slightly calcareous		17 0

No further seams of coal higher in the series than the one last mentioned as being 1 foot 2 inches thick occur, and the beds can be observed gradually losing the true type of the Barákar rocks, and passing almost imperceptibly into those of the middle division of the Damoodah. Carbonaceous shales with ironstones, at first occasionally and then more abundantly, are intercalated with Barákar sandstones, until finally all traces of the lower division disappear, opposite Putrakoolhee. In this river it is impossible to discover any unconformity in dip between the two

groups, or any evidence of the denudation of the one previously to the deposition of the other.

The above section is an excellent one, to show the approximate actual amount of coal contained in the Barákars, for, owing to the absence of wood, the poorer people living in the villages along the banks of the Kuttree, are driven to the necessity of cutting into these seams to obtain fuel both for cooking and warming purposes; thus exposing the coal well to view, and enabling one to measure with rather more satisfactory results than is usually the case.

Including all the seams, both large and small, the actual amount of coal determined is 73 feet, but allowing for the seam No. 40, it may be computed at 100 feet, which is the probable thickness of coal occurring all through the Jherria field in this group.

Opposite to Rampoor a nullah falls into the Kuttree on its left bank, and a little way up it, a seam 3 feet in thickness is seen. It is cut into, but is not of good quality. Lower in the section is another seam, 1 foot, below which, shales and sandstones similar to those in the Kuttree and Busjooreea are seen.

Pebbles, as usual, occur throughout them.

Section of the Bugdiggee nullah.—The first coal above the grits and coarse sandstones occurs west of Butmoorna, in a seam (of which only 4 feet are visible) cropping out in the middle of the stream. The dip is 8° south.

Coal at Butmoorna.

Near Koireedeeh, fresh-water limestone is at present forming of a crystalline texture, and light bluish grey colour. It contains imbedded in it fragments of quartz, felspar, and some varieties of fresh-water shells, such as *Melania*, *Paludina*, and *Planorbis*.

Limestone near Koireedeeh.

Succeeding the coal seam near Butmoorna are fine siliceous sandstones, and 200 yards further down a partial outcrop is seen. Carbonaceous shales begin to occur plentifully, and many have tesselated bands of ferruginous shale. Some 20 feet higher in the series, there is another seam, but its thickness is also obscured.

The section becomes clear opposite Taytooreea, and the number of beds of coal surpasses any thing yet observed. Most of them have been cut into; the large villages of Mailkerra, Daygaon, and the smaller ones whose inhabitants are chiefly Sonthals, being supplied principally from the seams of this nullah.

The strata, in ascending series, are—

		Ft.	In.
1.	Coal seam exposed three times. Dip 7°	2	6

	Ft.	In.
Coal ...	1	7
Parting ...		1
Coal ...		10
Total of *coal* ...	2	5

The 10-inch coal is very bright.

2.	Thinly laminated brown siliceous shales, containing numerous fossil plants...	4	0
3.	Slightly carbonaceous siliceous shales, with concretionary structure (uncertain)	5	0
4.	*Coal*. Dip 10°		3
5.	Dark carbo-siliceous shales	1	4
6.	Brown siliceous sandstones containing faint plant impressions, and thinly laminated carbo-siliceous shales. Dip 10°	10	0
7.	Thin carbonaceous shales	1	0
8.	*Coal*	4	0
	This is not quite clear, being nearly all covered up with sand.		
9.	Siliceous and micaceous shales, with thinly laminated carbonaceous shales (about)	18	0
10.	*Coal* seam. Dip 8° S. by E. (about)	8	4

	Ft.	In.
Coal (about)	3	1
Parting (do.)		9
Coal (do.)	4	6
Total of seam ...	8	4

These thicknesses were determined as well as the circumstances would permit. Water flowed over the outcrop of the seam.

11.	Fine grained, flaggy siliceo-carbonaceous shales	47	6
12.	*Coal*, of very superior quality, and extensively used	6	3
	Amount carried forward ...	108	8

		Ft.	In.
	Amount brought forward ...	108	8
13.	Light grey argillaceous shale, with strings of *coal*		9
14.	Argillaceous shales, white near their outcrop, but slightly coloured by carbonaceous matter below	5	0
15.	Conglomerate band		6
16.	Coarse grained white siliceous sandstone containing a few small pebbles	4	6
17.	Similar beds intercalated with shales	45	0
18.	*Coal* (indistinct)	2	0
19.	Flaggy carbonaceous shales with a 2-inch seam of coal	18	0
20.	Siliceo-micaceous shale	8	0
21.	*Coal* seam. Dip 10°	2	7

	Ft.	In.
Coal (inferior)	1	2
Carb. shale	1	0
Coal		5
Total of *coal* ...	1	7

		Ft.	In.
22.	Carbonaceous shale...	1	0
23.	Brownish grey arenaceous shales, containing quartz, pebbles, and conglomerate bands	17	0
24.	Carbonaceous siliceous shales containing plants	17	6
25.	*Coal* seam	7	2

	Ft.	In.
Coal	3	4
Parting		4
Coal	3	6
Total of *coal* ..	6	10

The bottom portion, 3 feet 4 inches, is the best, but it is much mixed up with iron.

		Ft.	In.
26.	Hard slaty shale	1	0
27.	Light sandy shale	3	6
28.	Carbonaceous shale	1	2
29.	Sandy micaceous shale	1	9
30.	Dark carbonaceous shale	2	6
31.	Grey argillaceous shale	2	0
32.	Ferruginous shale		9
33.	Brownish massive sandstone spotted by iron	6	0
34.	Carbonaceous shale	2	0
35.	Sandstone and grey argillaceous shale	12	0
	Nothing is then seen for seven yards.		
36.	*Coal* seam. Its thickness can only be arrived at approximately; it is about	15	0
	The coal is compact, has a shining lustrous appearance, burns with a clear bright flame, and intumesces slightly.		
37.	Sandstones containing pebbles ... ... 40 to	50	0
38.	Arenaceous shales	30	0
39.	False-bedded sandstones containing pebbles	15	0
40.	Micaceous and sandy shales	14	0
41.	*Coal* seam	3	9

	Ft.	In.
Coal	1	0
Shaly parting	1	8
Coal		6
Ironstone shale		5
Coal		2
Total of *coal* ...	1	8

		Ft.	In.
	Amount carried forward ...	398	1

		Ft.	In.
	Amount brought forward ...	398	1
42.	Siliceo-carbonaceous shale		10
43.	Sandy micaceous shale		4
44.	Dark slightly carbonaceous shale	2	7
45.	*Coal*	3	10
46.	Sandy micaceous purplish shales, and yellow calcareous sandstones	13	0
47.	Flaggy purplish shales, and sandy shales, all, more or less, coloured by carbon	10	6
	Dip 10° S.		
48.	*Coal* seam	5	8

	Ft.	In.
Coal	1	5
Parting		3
Coal	2	7
Parting, hard shale		5
Coal	1	0
Total of *coal* ...	5	0

		Ft.	In.
49.	Micaceo-siliceous shales	8	0
50.	Carbonaceous and argillaceous shales	5	0
51.	*Coal* seam	5	2

	Ft.	In.
Coal	2	4
Ironstone		1½
Coal		8
Brown arenaceous parting ...		5
Coal	1	0
Inferior coal, with brown arenaceous laminæ		8
Total of *coal* ...	4	0

		Ft.	In.
52.	Slaty carbonaceous shale	1	0
53.	Reddish brown sandstone (freestone)	2	6
54.	Thick false-bedded slightly calcareous sandstone	44	0
55.	Micaceous dark blue shales	11	0
56.	White false-bedded sandstone	4	6
57.	Sandy micaceous shale	3	6
58.	Carbonaceous shale passing into coaly shale	1	7
59.	*Coal*. Dip 13°	1	1
60.	Light brown sandy micaceous shales	33	0
61.	Underclay		5
62.	*Coal*		10
	This is seen again round the next bend of the river.		
63.	Sandy shales	9	0
64.	Conglomerate band		6
65.	Micaceous slightly calcareous sandstone	6	6
66.	Carbonaceous shale	4	0
67.	*Coal*		3
68.	Argillo-micaceous shale	12	0
69.	Underclay	1	0
70.	Coaly shale		8
71.	Brown micaceous sandstone		10
72.	Grey micaceous shale		6
	Amount carried forward ...	591	8

		Ft.	In.
	Amount brought forward ...	591	8
73.	Underclay containing plants	1	2
74.	*Coal* seam	3	5

	Ft.	In.
Coal	1	10
Parting		5
Coal	1	2
Total of *coal* ...	3	0

The upper portion of this seam is very good.

		Ft.	In.
75.	Clay shale		6
76.	Grey and brown micaceous shales with carbonaceous matter ...	7	0
77.	*Coal*	1	1
78.	Carbonaceous slaty shale	1	1
79.	Brownish grey concretionary argillaceous shale	3	0
80.	Arenaceous shales	29	0
81.	*Coal*	1	0
82.	Ordinary shales	52	0
83.	*Coal* seam	4	6

	Ft.	In.
Coal	1	9
Parting		7
Coal	2	2
Total of *coal* ...	3	11

		Ft.	In.
84.	Slaty shale		10
85.	Sandstone	1	4
86.	Arenaceous shales	13	6
87.	Carbonaceous shale		9
88.	Micaceous sandy shale	1	6
89.	*Coal*		9
90.	Coaly shale		9
91.	Micaceous dark shaly beds; and yellow calcareous sandstones ...	23	0
92.	*Coal* seam	4	9

	Ft.	In.
Coal	2	4
Parting argillaceous shale ...		5
Coal		8
Parting of argillaceous ironstone ...		4
Coal	1	0
Total of *coal* ...	4	0

		Ft.	In.
93.	Carbonaceous and argillaceous shale	3	6
94.	Coaly shale		4
95.	Micaceous shale and sandstone	11	0
96.	*Coal* (cut into)	1	0

It crosses over to the other side of the river, and is only 3 inches thick; the other 9 inches being light grey argillo-micaceous shale.

		Ft.	In.
97.	Micaceous and carbonaceous shales, with yellow flaggy sandstones ...	26	0
98.	*Coal*		5
99.	Black slaty carbonaceous bed	1	0
	Amount carried forward ...	785	11

			Ft.	In.
	Amount brought forward	...	785	11
100.	Sandy shales, with yellow flaggy sandstone at top ...	...	13	0
101.	*Coal* seam	...	8	10

	Ft.	In.
Coal	2	6
Argillaceous light-grey shale...	3	0
Coal	1	6
Micaceous sandy shale ...	1	6
Coal		4
Total of *coal* ...	4	4

			Ft.	In.
102.	Grey sandy and carbonaceous shales	...	8	0
103.	*Coal* seam	...	5	0

	Ft.	In.
Coal	2	8
Parting, argillaceous shale ...		6
Coal	1	10
Total of *coal* ...	4	6

			Ft.	In.
104.	Grey argillaceous shale, and carbonaceous slaty shale containing nodules of iron	...	2	6
105.	*Coal.* Dip 15° (about)	...		8
106.	Yellow flaggy sandstones and shales	...	23	0
107.	Coaly shale	...	2	0
108.	Grey argillo-micaceous, and dark carbonaceous shales containing ironstone	...	13	0
109.	Carbonaceous shale and ironstone	...	5	0
110.	*Coal* 1 ft. 10 in. to ... ... (This seam is seen three times.)	...	2	0
111.	Carbonaceous shale	...		7
112.	Siliceo-argillaceous shales	...	18	0
113.	*Coal*	...		6
	Total	...	888	0

The thickness of this section is nearly 900 feet, and it contains 91 feet of coal within a distance not much exceeding a mile; and from the great prominence of the coal, and carbonaceous shales, and shales slightly coloured by carbon, the Bugdiggee River might well be called the 'black nullah.' The best coal is contained in the seams Nos. 12 and 36. They both burn brightly and clearly, but the quantity of ash is 15 per cent.

Section of the Khodo Nuddee.—The lowest bed containing an approach to coal is where the river for the first time bends eastwards, after leaving the Talchirs. The thickness is 2 feet 6 inches, of which 1 foot 3 inches is coal, with a dip of 8° south by east.

Then succeeds grey-micaceo-felspathic quartzose sandstone, 17 feet, having a dip of 7°; then a seam which cannot be measured properly. One foot 9 inches of inferior coal is all that can be seen. South of Moorardeeh this same seam appears in a shallow stream, having a total thickness of 7 feet and a dip of 5°. The next rocks are—

		Ft.	In.
1.	Sandstone and shaly sandstone	3	7
2.	True Barákar grits, with two to three bands of carbonaceous shales	68	0
3.	*Coal* seam. At the lowest computation its thickness cannot be less than 60 feet; a very considerable portion of it, however, is nothing more than coaly shale, which is totally unfit for use; but in this instance as in many others the exact section cannot be given. Its outcrop is visible along both margins of the river, and extends, on the one hand, nearly to the village of Jumooatand, where its edge is turned up; and on the other, to the large trap dyke east of Baihyardeeh. Portions of the seam are worked, but the quality is bad. The dip varies from 7° to 10°. Two dykes intersect it in the river; one near the western end, and the other at the eastern end of the reach in which it occurs.	60	0
4.	Coarse sandstones	64	0
5.	Beds indistinctly seen, but apparently carbonaceous-shales. Dip 12°	28	0
6.	Felspathic quartzose sandstones	12	0
7.	*Coal* seam, lower portion not seen. Dip 7°. Thickness visible ...	3	0
8.	Sandy shale	1	0
9.	*Coal* (inferior)	2	0
10.	Shale, carbonaceous		8

Coal at Toondo.

The strata lower down the river to the large dyke crossing from Jogeedeeh to Toondo are too indistinct to measure. The next seam is seen opposite Toondo. It is nearly horizontal, and at the most does not dip more than 5°. The section is then obscured, to the next bend of the river, where a seam 2 feet 10 inches occurs, dipping to the north-east to east-north-east. The amount of coal and shale varies considerably along its outcrop, as the following measurements taken within the length of 100 yards, will show:—

		Ft.	In.
11 α.	*Coal*	2	10
β.	Thinly laminated carbonaceous shale		2
γ.	Grey siliceo-argillaceous shale and ironstone ...	2	0
δ.	*Coal*		

	2nd.	Ft. In.
α.	*Coal* (corresponding to 2 ft. 10 in., but not measurable).	
β.	Carbonaceous shale	2
γ.	Grey arenaceous shale	1 10
δ.	*Coal*	3 0
	3rd.	
α.	*Coal*	
β.	Shale .. .. 4 / *Coal* .. .. 2 / Shale 4	10
	4th.	
α.	*Coal* decreased in thickness	2 4
β. & γ.	Grey arenaceous shale	3 0
δ.	*Coal*	3 0

The section from this point becomes clear, and the dip reverts to its usual direction. The beds are inclined at high angles, and it is probable that this area was one of local weakness, of which the prevalence of large basaltic dykes may be taken as some proof.

		Ft.	In.
12.	Carbonaceous shale	1	6
13.	Sandy micaceous shale		6
14.	*Coal*. Dip 8°		8
15.	Sandstone	27	0
16.	Carbonaceous sandy shales	4	0
17.	*Coal* at corner (where the beds begin to dip high)	1	2
18.	Sandstones containing pebbles. Dip 10°	35	0

The Kurree-Joor here joins the Khodo.

		Ft.	In.
19.	Thinly laminated carbonaceous and coaly shale; also purplish micaceous shales. Dip 30°	25	0
20.	*Coal*. Dip 30°	1	6
21.	Micaceous slightly carbonaceous shales, with two beds of coaly shale	86	0
22.	*Coal*. Dip 40° to 42° on the left bank. On the right bank its dip is only 30°	4	2

A small fault occurs here, which can easily be traced across the river. It causes the difference in the amount of the dip, in the above seam, as seen on the upthrow and downthrow sides.

		Ft.	In.
23.	Sandy shales containing pebbles	16	0
24.	*Coal*. Dip 30° to 32° due south	1	0
25.	Micaceous shale	4	0
26.	*Coal*	2	6
27.	Grey siliceo-carbonaceous shales	4	0
28.	*Coal*	3	0
29.	Grey micaceous shales	9	0
30.	*Coal* seam	10	0
31.	Greyish micaceous shales, and slightly calcareous sandstones ..	60	0
32.	*Coal* seam	2	9

	Ft.	In.
Coal	1	6
Ironstone parting		4
Coal		10
Total of *coal* ..	2	4

		Ft.	In.
33.	Siliceo-argillaceous shales	15	0
34.	Coaly shale	2	0

		Ft.	In.
35.	False bedded sandy shales containing pebbles, alternating with grey micaceous shales	25	0
36.	*Coal* (inferior)	1	0
37.	Grey argillo-arenaceous shales	87	0
38.	*Coal* and carbonaceous shale with trap. Dip 35° S. S. E. by S. ..		
39.	Sandy shales	21	0
40.	*Coal* seam. Dip 28°	6	10

	Ft.	In.
Coal	1	6
Carbonaceous shale	2	0
Coal	3	4
Total of *coal* ..	4	10

		Ft.	In.
41.	Brown sandy shales, and purplish micaceous shales	131	0
	Gobinpoor to the north. The river turns and runs along the strike of the beds.		
42.	Coaly shale		6
43.	Yellow micaceous sandstone	1	6
44.	Carbonaceous shale	1	0
45.	*Coal.* Dip 22°	4	0
46.	Varying shales, and shaly sandstones	42	0
47.	Slightly calcareous sandstone	4	6
48.	Sandstones and grey micaceous shales	40	0
49.	*Coal*		4
50.	Ferrugino-siliceous shale	1	6
51.	Grey and brown sandy shale	16	8
52.	Coaly shale	1	2
53.	Micaceous sandstones containing pebbles and boulders	12	6
54.	Red ferruginous shale		3
55.	*Coal*	1	4
56.	Thin micaceous shaly sandstones	79	0
57.	*Coal.* Dip 15°		4
58.	Arenaceous shaly sandstones	5	6
59.	Yellow calcareous sandstone	1	0
60.	Shaly sandstone	4	0
61.	Carbonaceous shale, coaly at bottom	3	10
62.	*Coal* with trap. Immediately south of the junction between the Brahmundeeha and Khodo nullahs	1	0
63.	Arenaceous sandstones and shales	43	0
64.	*Coal*	1	0
65.	Carbonaceous shales and sandstones, some of the latter slightly calcareous	87	0

The river then runs along the strike of the beds, and afterwards bends backwards and forwards, so that the same strata are exposed three times. The section of the above beds, when seen in the last bend, differs from that near the mouth of the Brahmundeeha nullah. The trap becomes stronger, and forms two dykes standing up prominently in the bed of the river. The section is—

	Ft.	In.	
Coal	1	4	No. 62.
Sandstones containing boulders, and subordinate beds of shale	37	0	No. 63.
Dyke.			
Dark sandy slightly carbonaceous shales with a coal seam 8 inches	25	0	

Ft. In.

Dyke.

Coal, injured	2	0	No. 64, and part of No. 65.	
Coaly shale and sandy micaceous shale ..	1	0		
Coal	1	0		

Sandstones and purplish micaceous shales. Dip 15°

The next bed is—

66. *Coal* seam.. .. .. 4 5

1st Section.		Ft.	In.	2nd Section.		Ft.	In.
(*a.*)	*Coal*..		10	(*a*)	*Coal* ..		10
(*b.*)	Soft dusty shale ..		2	(*b.*)	Ironstone ..		2
(*c.*)	*Coal*..		6	(*c.*)	*Coal* ..		4
(*d.*)	Sandy parting ..	1	5	(*d.*)	Carbonaceous shale..	1	0
(*e.*)	*Coal*		6	(*e.*)	*Coal* ..		9
(*f.*)	Ironstone parting ..		2	(*f.*)	Ironstone ..		2
(*g.*)	*Coal* ..		7	(*g.*)	*Coal* ..	1	2
	Total of seam ..	4	2		Total of seam ..	4	5
	Total of *coal* ..	2	5		Total of *coal* ..	2	11

This is an instructive example of the variations in the thickness of coal and partings in a seam.

67. Flaggy purplish micaceous-sandstones and sandstones slightly calcareous 20 0

68. *Coal* seam 2 2

	Ft.	In.
Coal	1	2
Micaceo-carb shale		6
Coal		6
Total of *coal*	1	8

69. Arenaceous shales, some made up of alternating white and black bands 27 0

70. *Coal* 5

71. Sandy and micaceous shales, the latter slightly carbonaceous ..

72. *Coal* seam 6 4

1st Section.	Ft.	In.	2nd Section.	Ft.	In.
Coal	3	2	*Coal*	3	4
Slaty shale ..	2	8	Slaty shale ..	2	0
Coal		6	*Coal*	1	0
Total of *coal* ..	3	8	Total of *coal* ..	4	4

NOTE.—This seam can only be seen when the natives clear away the sand, for the purpose of extracting the coal.

Whilst encamped at the village of Dhurmoband opposite to this seam, I could obtain no information regarding it. Both the Zemindar and Chowkeedar denied the occurrence of any coal in their neighbourhood; they as well as the other inhabitants labouring under the impression that I had come with the intention of fining them for using it. I subsequently discovered that on several occasions when I was encamped near some coal locality, the villagers tried to hide all evidence of their having worked a seam, shovelling in sand and mud to obscure the outcrop.

		Ft.	In.
73.	Sandy micaceous shales	17	6
74.	*Coal* thinly laminated		6
	Some other outcrops are evident from the occurrence of black muddy stuff in the banks, but they are all too indistinct to be properly made out. The section is no doubt similar to that of the Bugdiggee.		
75.	Beds obscured by water and stones (about)	62	4
76.	*Coal*	2	0
	A few yards down the river, and then comes the mouth of the Bugdiggee.		
77.	Intermediate beds	7	0
78.	*Coal* seam. Dip 10° south	3	2

	Ft.	In.
Coal		7
Ironstone shale		1
Coal	1	5
Laminated carb-shale		7
Coal		6
Total of *coal* ...	2	6

		Ft.	In.
79.	Concretionary shales, and false bedded sandstones	17	6
80.	Slightly concretionary shales	1	8
81.	White micaceous felspathic sandstones	8	0
82.	Argillaceous shales	4	9
83.	Slightly calcareous sandstone		4
84.	Argillaceous sandstone		7
85.	Micaceous sandstone	1	6
86.	Concretionary shales	2	2
87.	*Coal*		8
88.	Flaggy carbo-arenaceous shales..	12	0
89.	Yellow micaceous slightly calcareous sandstones	4	0
90.	Ordinary micaceous sandstone	4	3
91.	Argillo-arenaceous shale	1	0
92	Coaly shale	1	5
93.	Conglomerate		2
94.	Thinly laminated grey micaceous sandstone	6	0
95.	Concretionary argillaceous shale	3	6
96.	Shale, lower portion containing *coal*		6
97.	*Coal*		8
98.	Conglomerate band		4
99.	Alternations of micaceous sandstones, (many of them calcareous,) and carbonaceous shales	30	0
	Then the beds on the right bank are inclined at a high angle. They occupy, however, a very small thickness, the strata reverting to an angle of about 14°.		
100.	Carbonaceous shales, and some sandstones false-bedded and slightly calcareous	193	0

NOTE.—These and the following beds are remarkably similar to the middle group of the Damuda series, but the nature of the Barákars is here so transitional that, from the presence of coal, I think we are justified in referring the section for the next 170 feet to the lower series.

A small anticlinal occurs, and then on the left bank—

		Ft.	In.
101.	Carbonaceous shales and ironstones are exposed imperfectly (about)	70	0
102.	Arenaceous shales and thin bedded sandstones	60	0
103.	Small seam of coaly *shale* on the left bank		6
104.	Micaceous and slightly calcareous sandstones, false bedded ...	34	0
105.	*Coal* seam		

Coal	... 4	Dip S. by W.
Parting	... 3	
Coal	... 6	

Total of seam	1	1
Total of *coal*		10

Dayoghurra opposite.

This makes the last seam in the section. Carbonaceous shales with ironstones succeed shortly, and with some slight breaks of continuity are very well seen down to the junction of the Khodo with the Kuttree, and from thence in the latter river to its confluence with the Busjooreea.

Reviewing the seams in the above section, the total amount of coal which can be acurately determined is 58 feet; but allowing in this case as in the Kuttree, for the seams which are not distinctly seen, the quantity is about equivalent to that seen in the latter stream.

The amount available, however, is different, as this depends entirely upon the size of the seam and the proportion that the coal bears to the partings. The same quantity of coal may occur throughout the whole of the series, but not the same available quantity. Not only in this river, but also in the Bugdiggee, the generality of the seams are small; as many as twenty in the present instance have coal under 2 feet in thickness, and only three or four have more than 6 feet.

Good coal.

The best seam is No. 72, and, though possessing only 4 feet of coal, its quality compensates in a measure for its small size. It again crops out in the Brahmundeeha nullah, and is the only seam cut into in that stream.

The district embraced between the Khodo and the Jummoonee shows several outcrops of coal; most of them, however, are indistinct, and cannot

be measured. In the Kurree Joor, Brahmundeeha, and Mudhoobun Nullahs, owing to the beds being cut through, some detailed sections can be given; but even in them the distinction between the quantities of coal and partings is not clearly seen; the lowness of the banks, and the fact of scarcely any of the seams having been even so much as dug into by the Kummars, being the principal reasons why this difficulty could not be overcome.

Sections obscure.

The area, about and west of the Khodo, is by far the most interesting in a geological point of view in the whole field. The Talchirs have a wider spread. Considerable denudation of the Barákars has taken place; an inlier of metamorphic rocks occurs, numerous dykes are present, the strata are more disturbed, and the largest seams of coal appear amongst the beds.

Section of the Brahmundeeha Nullah.—This section commences just above its junction with the Khodo.

Three small dykes crossing the Rajgunj road can be traced to the Brahmundeeha Nullah, altering a seam of coal. After which in ascending scale come two seams, respectively 2 and 1 feet, and then the seam corresponding to No. 72 of the Khodo Section.

Bottom to top.

	Ft.	In.		
Coal	2	0		
Shale	0	4		
Coal, very good	2	0		
Total of seam ..			4	4
Coal			4	0

The dip is 15° south. The coal is excellent, and when burnt leaves only a small quantity of ash. It possesses a bright lustrous appearance and closely resembles the Koosoonda coal.

The succeeding beds are felspatho-siliceous sandstones, and purplish and sandy shales, above which two inferior seams, each 3 feet thick, occur. Some carbonaceous shales and ironstones next appear, and finally

a small bed of coal 10 inches thick, with one of 4 feet a little higher in the section.

The river is banked up at this point; and nothing more is seen.

Local contortion.

South of Deogurha is a low table land of hard siliceous sandstones, and cropping out from under them are some red argillo-micaceous shales which exhibit along a portion of their strike near Baboodeeh, a northerly dip. This dies out as we proceed east or west; and to the south it reverts again to its normal direction. Some disturbance has taken place in the beds occurring about this neighbourhood, the strata exhibiting flexures and high dips. East of Nowagurh they suddenly increase in their angle of inclination, and further to the north near Burrora the beds form a hollow. As a rock very generally accompanying, and along the line of which these variations in the angle of inclination occur, yellow slightly calcareous sandstones are conspicuous.

Laterite.

The surface in places has little patches of laterite, derived from the waste of underlying micaceo-ferruginous shales. This rock is obviously the result of local action, and in this respect distinct from the larger areas of laterite seen to the east in the Raneegunj field.

Coal near Nowagurh.

Coal occurs at Nowagurh, the northern portion of that town standing upon a seam of which about 3 feet is seen.

Section of the Kurree Joor.—This small feeder of the Khodo falls into it, nearly opposite the Sonthal village of Gobinpoor, and some large seams are cut through by it. The highest in the series occurs west of the two large dykes, and is about 64 feet thick, having a horizontal extension of 100 yards across the strike, and a dip of 8°. This seam is traceable to the south of Doomra. Its quality appears inferior.

The river then runs nearly north, close to the most westerly dyke, and after a short distance passes through it, flowing in an easterly direction. Between the dykes no coal occurs, a bed of carbonaceous shale, 4 feet thick, only being seen. Near the junction of the nullah, however, with the Khodo, a seam crops out possessing the following section :—

	Ft.	In.
Carb. shale.		
Coal somewhat slaty, the lower portion impregnated by iron ...	2	8
Carbonaceous shale	1	0
Coal	2	6
Carbonaceous shale and *coal*	8	0
Total	14	2

This cannot be traced to the Khodo, and it is possible that a fault cuts it off, as the beds are somewhat disturbed to the east of it.

Seam near Mundra and Jairamdeeh.

Of other seams, there is one south of the Doomra or Mundra seam; and another, higher in the series, passing north of Jairamdeeh, and a little north of Nadkhurkee, corresponding to No. 34 of the Jummoonee section (page 297). Two small seams crop out near the tank at the south-east end of Jairamdeeh. The proportion of coal to partings in all of these is small, and there appears to be enough of useless matter seriously to lessen the value even of the larger seams.

The sandstones and shales south of Jairamdeeh form a hardened ridge, stretching from Asookhootee to the south of Nadkhurkee. They have been altered by trap, of which pieces can be found here and there. Several of the coal seams are also affected by it, two south of the ridge and three north of it.

Coal near Pundooabheeta.

About Pundooabheeta and Beneedeeh several outcrops are visible, but as they form the continuation of those in the Mudhoobun Nullah, their occurrence in this locality is merely mentioned without giving their thicknesses in detail.

Section of the Mudhoobun Nullah.—Commencing the section south of the ridge, white false-bedded micaceous and felspathic sandstones containing boulders and pebbles are first met with, then sandy and carbonaceous shales.

The lowest seams are merely indicated by black coaly-looking mud in the banks.

Section, bottom to top.

			Ft.	In.
Black mud (coal?)			2	2
Ferruginous parting				6
Black mud (coal ?)			2	8
Siliceo-micaceous shale			3	6
Coal			1	0

Nothing then is distinct until we get the seam worked by the natives. It is exposed twice by the winding of the river, and unless care be taken, its true relations would be mistaken, as a seam higher in the series is seen first. The section is—

			Ft.	In.
1. *Coal* seam			5	1
Coal	0	6		
Black laminated carb. shale ...	0	4		
Coal (bright lustrous)	1	4		
Ironstone parting of variable thickness	0	4		
Coal	2	7		
Total of *coal*			4	5

This is the only seam from which coal has been extracted, most of the others being stony. The dip is about 10,° but within short distances it varies suddenly.

			Ft.	In.
2. Black siliceo-micaceous shale			1	1
3. Light brown micaceous sandstone with carbonaceous markings ...			1	4
4. Ferruginous underclay			0	2
5. *Coal*, superior			2	6

Dyke.

			Ft.	In.
6. Argillo-micaceous sandstones			10	0
7. *Coal* seam			8	5
Coal with trap	4	4		
Argillaceous and carbonaceous shale ...	1	8		
Inferior coal and shale	1	4		
Trap		9		
Coal		4		
Total of *coal*			6	0

The rocks are then obscured; and the next coal occurs at the spot where the river is joined by a little stream on the right bank. The section is—

			Ft.	In.
(*a.*) *Coal* seam			5	6
Coal	1	10		
Shale		8		
Coal	3	0		
Total of *coal*			4	10

		Ft.	In.
(*b.*)	Siliceo-micaceous shales	3	0
(*c.*)	*Coal.* Dip 17°	1	0
(*d.*)	Carbonaceous shales		8
	Then about 60 feet higher in the series is an injured seam. The bottom portion is indistinct.		
(*e.*)	*Coal* seam	5	6

	Ft.	In.		
Coal (not all seen)	3	0		
Trap				
Coal	2	6		
Total of *coal*			5	6

		Ft.	In.
(*f.*)	Sandstones	36	0
(*g.*)	*Coal* seam	2	3

	Ft.	In.		
Coal		6		
Parting		2		
Coal	1	7		
Total of *coal*			2	1

The dip now gradually increases from 15° to 25°.

Ninety to a hundred feet above the last seam is another measuring 2 feet 6 inches. Thirty feet or so and then a second, about 7 feet thick, and fifty feet above this again is a third, 5 feet, dipping at an angle of 25°.

From this point to its junction with the Jamdeeha Nullah no more coal is visible, and the section is broken and imperfect.

NOTE.—The seam No. 1 cannot now be seen in the river, as the villagers of Nadkhurkee have banked up the stream to make a tank of it.

Section of the Jummoonee.—Proceeding westwards, the next section is that of the *Jummoonee.* Here for the first time we obtain a really good view of the lowest beds of the Barákars, none of them being hid by sand. The river throughout its entire course is rocky; and its sides covered with jungle, and often high, present an aspect of considerable beauty, more especially when contrasted with the low-banked streams whose sections we have hitherto only considered.

Pudding-stones.

The conglomerates, or pudding-stones, at the base are well seen, occupying a thickness of 40 or 50 feet. They are still better developed to the west; and in the Bokaroh field are very conspicuous, forming three high escarpments along its northern boundary. The general tendency of the beds in fact is to become coarser as they extend westwards, and

even the Talchirs lose the greater mass of the needle-shales; sandstones replacing them. Coarse grits and felspathic sandstones, the latter containing pebbles, are very steady, and well represented in the following section.

The seams of coal are numerous, and several of them are of large size; but it is questionable whether many of them would repay extraction, as they contain a large proportion of worthless shale. This point, however, is more fully referred to in the sequel.

The section is as follows :—

The lowest strata are transition beds, and the first really definite bed of the Barákars is—

		Ft.	In.
1.	Micaceous shales, containing carbonaceous remains	10	0
2.	Conglomerate band	1	0
3.	Siliceous fine grained sandstone (about)	20	0
4.	Pudding stone	13	0
5.	Siliceo-micaceous sandstone	6	0
6.	Underclay	1	4
7.	*Coal*	1	0
8.	Pudding stone	10	0
9.	Siliceo-micaceous slightly carbonaceous shale	3	6
10.	Slaty shale		3
11.	*Coal*		9
12.	Grit-stone	2	0
13.	Sandstone	7	6
14.	Carbonaceous shale	1	6
15.	Conglomerate band		6
16.	Grit-stone, containing scattered pebbles, and nests of same ...	26	0
17.	*Coal* (inferior)	6	0
18.	Gritty sandstone	13	0
19.	Slaty carbonaceous shale	6	0
20.	*Coal*	1	0
21.	Slaty shale		3
22.	Gritty band		4
23.	Hard siliceous sandstone	2	0
24.	Carbonaceous shale...	1	6
25.	*Coal* seam. Dip 6°	9	0

	Ft.	In.
Coal	2	6
Shale and coal	1	0
Shale, light grey	1	6
Coal	4	0
Total of *coal*	7	0

This is the seam cut by the villagers of Khanoodeeh. The lower portion is not well seen.

		Ft.	In.
26.	White coarse felspathic siliceous sandstones with a few subordinate beds of shale	130	0

	Ft.	In.
27. Coal seam, extending north of Mutteegurra. It is splendidly developed inland, and forms two terraces, along one of which a village road has been made. Portions of it contain coal, but the greater mass is entirely composed of carbonaceous shales. The dip is variable, being at the base 40,° higher up 22,° and near the top 10° and 12°. Its horizontal extension across the strike is 500 feet, and the following are the measurements in the river, giving it a total thickness of	126	0

				Ft.	In.
50 feet dip		35°	=	28	0
50	„	25°	=	21	0
50	„	20°	=	17	0
350	„	10°	=	60	0
Total of seam			..	126	0

	Ft.	In.
28. Sandy brownish shales; sandstones and micaceo-carbonaceous shales	52	0
29. *Coal* seam, slightly variable in thickness	7	7

1st Section.	Ft.	In.	2nd Section.	Ft.	In.
Coal, with much iron in it ..	2	6	*Coal* (inferior) ..	6	7
Ferruginous parting ..		2	Parting ..		1
Coal	3	2	*Coal* (inferior) ..	1	0
Shaly parting ..		1			
Coal (good) ..	1	4			
Total of *coal* ..	7	0	Total of *coal* ..	7	7

3rd Section.	Ft.	In.
Hard stony coal	2	0
Coal (inferior), bottom portion coloured by iron ..	4	0
Parting		1
Coal (inferior)		8
Carbonaceous shale		2
Coal and coaly shale		8
Total of *coal*	7	0

	Ft.	In.
30. Carbo-ferruginous shale	0	10
31. Conglomerate	0	2
32. White quartzose sandstones, containing pebbles of milky quartz ..	18	0
33. Carbonaceous shales, (about)	6	0
34. *Coal* seam (not of good quality)	18	6
35. Shales and sandstones containing pebbles. The dip increases suddenly from 10° to 45° (about)	70	0
36. Shales. Dip 10°	7	0
37. *Coal* seam with scarcely any partings. Dip 8°. It has been on fire.	21	6

The Mutteegurra Joor and the Jummoonee join here.

	Ft.	In.
38. Carbonaceous shales	40	0
39. Greyish white micaceo-felspathic siliceous sandstones and shales, the former slightly calcareous	57	0
40. False bedded sandstones containing pebbles	17	6
41. Carbonaceous shales	8	6
42. *Coal*, Dip 10°	13	0
43. Micaceous carbonaceous shales	42	0
44. *Coal*	1	9
45. Carbonaceous shales	9	0

		Ft.	In.
46.	False bedded felspatho-siliceous sandstones containing pebbles, scattered and in nests	28	0
47.	*Coal* seam, with two bands of trap	14	6

	Ft.	In.
Amount of seam	11	0
Amount of trap	3	6

The quality of this coal is bad.

		Ft.	In.
48.	Alternations of carbo-arenaceous shales, and micaceo-felspathic arenaceous sandstone	45	0
49.	Reddish brown siliceous sandstones	5	0
50.	Carbonaceous shale..	2	2
51.	Micaceo-felspathic sandstone containing pebbles	8	0
52.	Carbonaceous shale	2	6
53.	Coaly shale		4
54.	Carbo-arenaceous shales	5	6
55.	*Coal*		3
56.	Conglomerate band..		3
57.	White felspathic sandstones containing pebbles	14	0
58.	Slightly concretionary carbo-arenaceous shales. Dip 22° to 23° ..	5	0
59.	*Coal* very inferior in quality, with a parting of ironstone in the middle	5	9
60.	Reddish brown arenaceous sandstone	1	5
61.	*Coal* seam	5	6

	Ft.	In.
Coal inferior at top	3	3
Arenaceous sandstone	1	0
Coal	1 0 to 1	3
Total of *coal*	4	6

		Ft.	In.
62.	Slaty carbonaceous shale .. .. .. 1 10 to	2	0
63.	False bedded siliceous sandstone	2	7
64.	Yellow micaceous sandstone	2	0
65.	Carbo-arenaceous shales	6	0
66.	Coaly shale	1	2
67.	Carbo-arenaceous shales	10	0
68.	Coal seam injured by trap. In this seam columnar structure induced by trap is most beautifully seen, and surpasses the examples that are shown in the Kurree Joor.		

A little lower down a dyke crosses the river, and the next coal occurs south of it. The section latterly has been measured on the left hand side, but for the next lower three hundred yards it is better seen on the right bank. A small fault having a south-east by south direction flings the beds a short distance, and the coal seam with trap is again met with lower down the river, Continuing the section from it, we get—

		Ft.	In.
69.	Hard arenaceous shale	18	6
70.	*Coal* and carbonaceous shale	27	0
71.	Sandstones and shales	62	0
72.	*Coal* (cut into). Dip 22°	7	10
73.	Brown arenaceous shales and false bedded ironstones containing pebbles	33	0
74.	*Coal* injured by trap	1	0
75.	Micaceo-arenaceous sandstones..	54	0
76.	*Coal* injured by trap	12	0
77.	Arenaceous and slightly carbonaceous shale	2	6
78.	*Coal.* Dip 22° south-south-east	3	0
79.	Carbo-arenaceous shales and sandstones	70	0
80.	*Coal*		5

		Ft.	In.
81.	Concretionary carbonaceous shales	4	4
82.	Yellow micaceo-calcareous sandstone	1	0
83.	Carbonaceous shale	1	3
84.	*Coal.* Dip 30°. The upper 3 feet are good	4	0
85.	Brown micaceous sandstones	95	0
86.	*Coal*		11
87.	Sandy shales	2	6
88.	Sandstone, with carbonaceous markings. Dip 27° to 30° south south-east	4	6
89.	Carbonaceous shale		2
90.	*Coal* seam	3	3

	Ft.	In.
Coal	1	9
Ferruginous shaly parting ...		3
Coal		7
Carbonaceous parting ...		1
Coal		7
Total of *coal*	2	11

		Ft.	In.
91.	Carbonaceous shale	0	9
92.	Sandy shales	2	6
93.	Argillo-arenaceous shale	2	0
94.	*Coal*	1	4
95.	Concretionary carbonaceous shales, and arenaceous sandstones, with a thin bed of coal..	11	6
96.	*Coal*, excellent		6
97.	Argillo-arenaceous shales and sandstones	16	0
98.	*Coal* affected by trap	1	6
	Coal not affected by trap		8
99.	Carbo-arenaceous shales	6	4
Then	succeed coals and carbonaceous shales injured by trap, which forms three ridges stretching across the river. The thickness of all is nearly 100 feet. The detailed section is—	100	0

1st ridge.

		Ft.	In.
a.	Carbonaceous slaty shale	1	4
b.	*Coal*	7	0
c.	Arenaceous sandstones, thin bedded	12	0

2nd ridge.

		Ft.	In.
d.	Areno-carbonaceous shales	11	6
e.	*Coal*	7	6
f.	Arenaceous and carbonaceous shales	5	3
g.	*Coal*, the lower portion of superior quality ...	2	7

3rd ridge.

		Ft.	In.
100.	Carbonaceous and micaceous siliceous shales. Dip 30°	100	0
101.	Brown siliceous sandstone and arenaceous shales	150	0
102.	*Coal* injured by trap		
103.	Greyish green, argillo-micaceous shales and sandstone containing pebbles	20	0
104.	*Coal*, inferior and shaly	1	0
105.	Argillaceous shales and sandstones, with carbonaceous shales ...	29	0
106.	*Coal*, inferior	2	0
107.	Carbonaceous shale and ironstone	9	0
108.	Grey argillaceous shales and yellow sandstones	10	0
109.	*Coal*, inferior. Dip 30° south south-east	0	6
110.	Intermediate beds, obscure, for 80 yards	120	0

		Ft.	In.
111.	*Coal* accompanied by trap		
112.	Argillo-carbonaceous shales, and calcareo-micaceous sandstones cut into by 3 dykes	125	0
113.	Sandstones and argillo-micaceous shales, and then another seam injured by trap	55	0
114.	Sandstones and shales	450	0

To these beds succeed a considerable thickness of very finely laminated argillaceous shales intercalated with massive sandstones, having altogether a thickness of 900 feet. These beds, no doubt, represent the middle series in the east of the field, but it is more than probable that at least half of them ought to be referred to the Barákars. There is clearly no unconformity between them and the underlying rocks, and it is quite arbitrary whether the whole be assigned to the one group or the other. No trace of an ironstone is visible—there is incipient concretionary structure due to the presence of iron; but nothing more. As the average thickness of the ironstones in the Khodo is about 600 feet, three hundred out of the nine may safely be put in the Barákar's, making that series, as developed in the Jummoonee, have a total amount of 2,900 feet.

In this section there are twenty-four seams of coal, measuring 1 foot and upwards, having an aggregate thickness (leaving out of the computation the Mutteegurra, or No. 27 seam), of 156 feet. Eleven of them are of workable thickness; the rest being either too small or too much mixed with shale to be of any value. The quality of the coals does not appear to be so good as those in the Kuttree and Kurree Joors. The samples submitted to examination, however, are all surface specimens, none of the seams having been cut by the natives owing to the abundance of wood in the neighbourhood. Iron throughout is abundant, and the percentage of ash great. The amount of inorganic matter would doubtless be less in pieces of coal taken deeper in the seam.

West of the Jummoonee,—no regular and continuous section is seen anywhere. The seams of the Jummoonee are exposed for short distances on its right bank, but are soon lost sight of.

The Mutteegurra, or No. 27 seam, is continued north of Sejooah. It is very irregularly permeated by trap. An excellent example of small faulting, causing a slight alteration in the direction of strike, occurs in it. The average dip is 12°.

In the nullah between Sejooah and Gootway, three seams crop out in the bank, dipping nearly south at an angle of 30°.

Pudding-stones near Hurdawa.

About ¼ of a mile due east of Hurdawa, the pudding-stone beds come in dipping to the east south-east; another small river occurs here running nearly up to Hurdawa, with beds dipping 15° south-south-west, differing in direction from those observed in the Sejooah and Gootway Nullah.

Seams near Kurmatand.

South of Kurmatand there is a Nuddee, and the beds near the metamorphic rocks dip at an angle of 55° south-south-west, but further down it decreases to 35°; where this latter dip obtains two seams occur, respectively 8 feet and 2 feet 6 inches, separated by 3 feet of carbo-argillaceous shales.

Section in Poro Nuddee.

Near Peepradeeh in the south-west portion of the field, a patch of Damúda rocks come to the surface. A section through them is seen in the Poro Nuddee. The Talchirs dip nearly south-west at 12°, and the first beds of the Barákars conform to them. Following the downward course of the river the section becomes obscure, and the next dip seen is a reverse one. Close to the southern boundary it is north to north-east, angle about 40°. A bed of very carbonaceous shale much twisted and crushed occurs here. Many portions are extremely ferruginous, and small lenticular bands of ironstone are seen throughout it. About 10 yards lower down comes the boundary.

Coal seam crushed.

West of the Poro Nuddee another river exposes a small band of the Barákar rocks. They consist of argillo-siliceous sandstones with two seams of coal. The coal is much crushed, and dips to the north-north-west. A little further up it is reversed to the south-east, angle of dip 42° to 50°.

In this small area there is nothing of the slightest economic interest; the seams of coal are all too poor, and too much crushed to be of any value, and the thickness of Barákars is so small that they present no new characters. The locality is much faulted. The northern boundary

between the Talchirs and metamorphics is marked by a breccia, and the southern one is also a fault running transverse to the strike of the beds. The other faults will be best understood by looking at the map.

The remaining portion of the field occupied by Barákar rocks, and which has still to be described, is the tract bordering the Damoodah, in the neighbourhood of Tasra, and the other villages west of it. It is very narrow, and, excepting in the rivers, the strata are not well seen. The beds throughout this area have a high dip, and therefore the seams of coal possess the same disadvantage as those west of the Jummoonee. The following is the section of the Tasra Nuddee:—

Beginning as usual at the base.

		Ft.	In.
	Metamorphic rocks.		
1.	Coarse white grit-stone (about)	2	0
2.	Carbonaceous shales and sandstones, rather confused (about) ..	10	0
3.	Grits with a few large pebbles, and many small ones of white quartz	6	0
4.	Carbonaceous shales principally, with two or three bands of sandstones at the top. Dip 50°	120	0
5.	Grit-stone	38	0
6.	Sand in the river, but at one bend some shales and sandstones are seen.		
	Calculation gives the thickness at (about)	115	0
	Dyke south-east to north-west.		
7.	Coarse felspathic sandstone	30	0
8.	Carbonaceous shale, with a small proportion of coal ..	15	0
9.	Grit-stone	22	9
10.	Argillaceous shale, slightly carbonaceous	7	6
11.	Coaly shale, breaking into splintery lenticular fragments, instead of displaying the characteristic squarish pieces of true coal ..	30	6
12.	Hid by sand and rushes, calculation (about)	35	0
	Dip 45°		
13.	Argillaceous and sandy shales	35	0
14.	Grit-stones and sandstones (about)	35	0
15.	Micaceo-siliceous shales	31	0
16.	*Coal* seam very imperfectly seen, only the upper 2 feet are clear. Total thickness	13	0
17.	Light grey micaceous and reddish ferruginous shales	10	0
18.	*Coal*, stony, and shaly at top	10	2
19.	Silica argillaceous shales	10	0
20.	*Coal* seam very slaty and inferior; much of it is only carbonaceous or coaly shale	41	0
	Dip 43° south-south-west by west.		
21.	Slightly carbonaceous micaceous shale	11	6
22.	*Coal*	4	0
23.	Slightly calcareous, reddish, micaceous flaggy bands, alternating with siliceous and ferruginous shales	34	6
24.	*Coal* seam (not of good quality) about	13	0
25.	Blueish carbo-micaceous shales	6	0
26.	*Coal* seam, section bottom to top—		

	Ft.	In.			
Coal		2			
Shale	2	0			
Coal		8	..	5	4
Carbo-micaceous shale	1	6			
Coal	1	0			
Total of *coal*			1 10		

No.	Bed	Ft.	In.
27.	Carbonaceous shale	2	0
28.	Siliceous shale	1	0
29.	Carbonaceous shale	3	6
30.	Compact, fine, and coarse-grained sandstones	48	0
31.	Light grey argillaceous shale	5	0
32.	*Coal* more or less hid (section obscure) about	14	0
33.	Grit-stones, with some interbedded carbonaceous shales 8 feet in thickness	52	0
34.	Carbonaceous shale	5	0
35.	*Coal* seam, inferior, only the middle portion 6′ 0″ is cut by the natives, the rest leaving too much ashes	18	0
36.	Grit-stones, with subordinate beds of carbonaceous shales ..	59	0
37.	Reddish siliceo-micaceous shales	8	0

Dip 40° south-west.

No.	Bed	Ft.	In.		Ft.	In.
38.	*Coal*	1	0	}	6	6
	Carbonaceous slaty parting ..	3	0			
	Coal	2	6			

Total of *coal* 3 6

No.	Bed	Ft.	In.
39.	Carbonaceous and sandy micaceous shales alternating with one another	65	0
40.	Coal seam (about)	7	0
41.	Sandstones, white felspathic; and siliceo-micaceous shales ..	110	0
42.	*Coal* seam (much mixed up with shale)	21	6
43.	Carbonaceous shales are seen at intervals cropping out in the banks of the river. No clear section is exposed for a distance of about 170 to 200 yards across the strike of the beds (calculated thickness about)	328	0
44.	Sandstones	8	0
45.	*Coal* injured by trap, thickness roughly	9	0

	Ft.	In.
Coal	5	0
Trap	1	0
Coal	3	0

No.	Bed	Ft.	In.
46.	Sandstone and carbonaceous shale	10	0
47.	*Coal* much cut into by the villagers; it burns brightly, and contains a lesser quantity of ash than the other coals occurring in the locality	11	0
48.	Carbonaceous shale	29	0

Trap.

No.	Bed	Ft.	In.
49.	Carbonaceous shales, and sandstones (about)	100	0

Trap hardening a seam.

A few more beds are seen, and then the section is obscured by mud and water.

Most of the coal in this river is of inferior quality; the only beds which can in any way be spoken favorably of are Nos. 38 and 47. The quantity of ash in the first is 14 per cent.

Coal south of Tasra.

Immediately south of Tasra there is a small cutting near the left bank of the Damoodah, where three seams are imperfectly exposed, dipping at an angle of 45° to 50°. About half a mile east of the village, a large seam, very much contorted and crushed, occurs in a ravine. It looks somewhat like anthracite, breaking with a sub-conchoidal fracture, and having a metallic lustre. The continuation of it is seen in the Domegurh Nullah, where a few seams dipping high are exhibited. One just at the junction of the nullah with the Damoodah is cut into.

The next section occurs in the *Chutkurree Joor*. The lowest strata are seen near Kareetand (called Chandrabad by the villagers themselves). The course of the river here is slightly tortuous, and it flows alternately through coal measures and gneiss rocks. A section of the beds that it exposes higher up has previously been given. It still flows through rocks of the same age; the Barákars being folded over in a great anticlinal, dipping away on both sides from the gneissic mass of Noneedeeh and Pargabad.

Below the point where the Purrusbunyan tank stream joins the Chutkurree, the beds are fairly exposed.

The section is (ascending)—

		Ft.	In.
	Metamorphic rocks.		
1.	Carbo-argillaceous shale	106	0
2.	*Coal* seam (about)	9	0
3.	Carbonaceous shale...	28	0
4.	*Coal* cut into, but inferior, being shaly	17	6
	Trap.		
5.	Carbonaceous shale	17	0
6.	*Coal*	1	2
7.	More or less carbonaceous shale, with red micaceo-siliceous sandstone, containing numerous plant remains	35	0
8.	*Coal*		6
9.	Coarse grit-stone	42	0
10.	Trap destroying coal for a considerable thickness, the horizontal extension is 50 feet		
11.	Carbonaceous shales	32	6
12.	*Coal*	4	0
13.	Sandstone, and shales alternating with one another	32	0
14.	Coaly shale	36	0
15.	*Coal* seam, inferior and shaly	28	0
16.	Shales, sandy, micaceous and ferruginous	66	0

		Ft.	In.
17.	Coarse felspathic sandstone approaching grit	8	0
18.	*Coal* seam, greater portion of it shale	32	0
19.	Shale, carbonaceous..	11	6
20.	*Coal*	2	0
21.	Micaceous shale	3	0
	Trap at corner where the river runs east nearly opposite Chasnala.		
22.	*Coal* seam. Dip 35°	16	0
23.	Micaceous and carbonaceous shales	10	0
24.	Compact grey sandstones	14	0
25.	Argillo-carbonaceous shales	15	0
26.	Grey compact sandstone	1	6
27.	Argillaceous shale	5	0
28.	*Coal* seam	22	10

	Ft.	In.
Coal (apparently)	8	6
Parting		6
Coal (ditto)	7	0
Parting		7
Coal (ditto)	6	3
Total of *coal*	21	9

		Ft.	In.
29.	Grey felspathic sandstone	85	0
30.	Carbonaceous shales	7	0
31.	Coarse granular sandstones	45	0
32.	*Coal* (inferior)	18	0
33.	Argillo-carbonaceous shales	28	0
34.	Grits and sandstones with some subordinate beds of shale ..		
	River hidden by sand for about 25 yards.		
35.	Sandstones and shales	90	0

From this spot to the Damoodah, the rocks are covered up by sand. The quality of the coal is much the same as that of the Tasra seams, and the dips are all high.

Coal near Chandrabad.

South of Chandrabad some indistinct outcrops occur in the cultivated ground. One seam measures 5 feet, above which comes another measuring 3 feet.

Section of the Pargabad Nullah.—In this nullah the beds are obscurely seen near Pargabad, coarse grits and white felspathic sandstones are the lowest rocks in the series. The first coal seam is about 9 feet thick, and occurs in the ghat between Mohulbunnee and Soolukdeeh. Higher in the series five others crop out, all dipping high and of inferior quality; near its outfall into the Damoodah is a seam 19 feet, which is the only one worth noticing. It is cut into by all the villagers around, whilst the rest are untouched. The coal burns well and makes an excellent fire. The quantity of ash that it contains is 18 per cent.

Section of the Jam Joor.—The next river to the west exhibits a better section. Near its mouth is a large seam with a dip of 35° fully 50 feet thick, cut off by a fault to the west. Then lower in the series follow two seams, respectively 7 feet 6 inches and 12 feet, dipping at 32°.

Below the last one we have—	Ft.	In.
1. Carbo-arenaceous (slightly micaceous) shales	21	0
2. *Coal*	2	6
3. Sandstone and shale	33	6
4. *Coal* seam	8	0
5. Arenaceous shale	10	0
6. *Coal* seam in the ghaut between Bhoma and Mohulbunnee about ..	12	0
7. Shales and coarse felspathic sandstones	168	0
8. Intermediate beds, obscure	22	0

Dyke bearing south-east by south.

A few feet higher up,

9. Coaly shale	2	0
10. Sandstones a few feet, and then another seam dipping to the south-west. After this the beds dip north-west by north, and the last seam is brought up again to the surface. Three or four more seams are seen; undoubtedly the same as those occurring lower down in the river; and then the stream is dammed up into a tank.		

In this, as in those of the previous sections made of this part of the field, there are seams amply large enough to be worked, but the great objection of their high dip precludes the possibility of any of them repaying the trouble and expense of extraction so long as much more favorably situated coal exists within a short distance.

Section of the Damoodah.—The section of the Damoodah exposes a few seams. South of Tasra the beds are twisted, and strike differently to those in the Chutkurree Joor. Three or four seams can be seen under water. No others are visible for some distance west of the Chutkurree. The first seam is about 2′ 0″ thick.

Section bottom to top ;—

	Ft.	In.		
Coal	0	4		
Parting		3		
Coal	1	5		
Total of *coal*			1	9

Then coarse felspathic sandstones and sandy shales; after which—

	Ft.	In.
Coal	1	0
Sandstones and shales		
Coal, the bottom part best	2	2
Carbonaceous shale and ironstone	4	0
Coal. Dip 45°	4	0

This coal was burning at the time of my visit, and it gave out a strong sulphurous smell. Beautiful little acicular and tabular crystals of sulphur were sublimed on various parts of the rocks, which presented two distinct systems of crystallisation, prismatic and oblique.

A few feet above comes the largest seam yet exposed :—

	Ft.	In.	Ft.	In.
Coal	2	2		
Ironstone	0	2		
Coal	3	8		
Total of seam			6	0
Total of *coal*			5	10

This is seen more than once in walking along the river, as its strike coincides very closely with the course of the stream.

These seams are higher in the series, than any of those noticed in the Pargabad or Jam stream.

The next coal is seen opposite Seedbaboodeeh, on the south side of the Damoodah, dipping 25° south-south-west. Its quality is very bad. This is the highest seam of the whole section.

Higher up the Damoodah, but lower in stratigraphical order, three seams occur, the lowest of which, 3 feet 6 inches thick, is twisted and contorted. All these dip to the south-west, but the succeeding beds change and dip northerly: amongst them are a few thin seams.

Directly south of Doongree, in the eastern reach of the river, the following is the section :—

		Ft. In.
1.	Concretionary argillaceous shales full of plant remains ..	
2.	*Coal*, divided by a parting	0 10
3.	Concretionary argillaceous shale, becoming coal at the bottom ..	3 0
4.	*Coal*	1 9 to 2 0
5.	Blue carbonaceous shales full of *vertebraria* stems, some of them 4 feet long	

Then north of the reach, there are two little seams on the left bank, respectively 2 feet and 6 inches, dipping north-north-east.

This is the last coal of the Barákars exposed by the Damoodah. Further to the west several seams occur, but they belong to the Ránigan j series.

The beds roll a good deal in this locality, and the boundaries between the ironstones and the Barákars wave about.

Section of the Kunjeea Joor.—The remaining section north of the Damoodah is that of the Kunjeea Joor. It does not expose the lowest beds of the series; white, fine grained felspathic thin-bedded sandstones containing boulders and pebbles being the first rocks that it cuts through.

The dip is 12° west-south-west, decreasing to 10° and 8°. The first coal occurs a little north of Noonickdeeh, and after that one or two more seams; the section was too indistinct to measure accurately; the last one appears to be about 7 feet 6 inches.

There is then a reverse dip, and the following beds appear:—

		Ft.	In.
1.	Shales dipping north-north-east		
2.	Carbonaceous and micaceous shales		
3.	*Coal*	1	6
4.	Shales	25	0
5.	*Coal* (about)	3	0
6.	Coaly shale	8	6
7.	Sandy shale	6	0
8.	Carbonaceous shale		
9.	*Coal* cut into, containing a large quantity of iron	11	1
10.	Carbonaceous shales, with runs of coal $\frac{1}{4}$ to $\frac{1}{2}$ an inch	11	3
11.	Coaly shale	1	9
12.	Carbonaceous shales, with one or two bands of ironstone... ...	13	6
13.	Sandstones and shales	27	0
14.	Shaly coal	4	0
15.	Sandy shales	4	2
16.	Carbonaceous and sandy shales	10	0
17.	Carbonaceous shales, with yellow flaggy sandstones	5	6
18.	Thin flaggy sandstones and shales	67	0
19.	*Coal.* (The upper 3 feet of inferior quality)...	14	0
20.	Flaggy micaceous shales	15	0
	Dip 22° N. by W.		
21.	Massive sandstones containing pebbles	3	0
22.	Carbonaceous light-grey shales	16	9

			Ft. In.
23.	False bedded sandstones		12 6
24.	Carbonaceous shales		6 0
25.	*Coal*	3 0	
	Parting, shaly	2 0	9 0
	Coal	4 0	
	Total of *coal*	7 0	
26.	Light grey and blue carbonaceous shales		12 0
27.	Flaggy sandstones		5 0
28.	Carbonaceous shales		30 0
29.	Micaceous slightly carbonaceous and siliceous shales with flaggy sandstones		20 0
30.	*Coal*		2 0
31.	Fine grained siliceous and felspathic sandstone containing large pebbles		30 0
32.	Micaceous shales and sandstones		6 0
33.	*Coal*	0 9	2 9
	Carbonaceous shale (blue)	2 0	
34.	Sandstones, fine grained and siliceous		9 0
	Dip 70°.		
35.	Micaceous sandstone and slightly carbonaceous shales alternating ..		56 0
	Dip 35°.		
36.	*Coal*	5 6	
	False bedded sandstone with pebbles ..	3 0	15 6
	Coal	7 0	
	Total of seam	15 6	
	Total of *coal*	12 6	
37.	Sandstone		4 0
38.	*Coal* (shaly)		5 0
	Dip 25° N.		
39.	Red micaceo-siliceous sandstone, with pebbles rippled		17 0
40.	Shales varying in composition		88 0
41.	Sandstones containing pebbles		20 0
42.	Carbonaceous shales weathering on the surface and containing runs of flaggy ironstone		7 0
43.	Reddish sandstones		2 0
44.	Felspathic thick bedded sandstone		5 0
45.	Carbonaceous shales and red flaggy beds of sandstone and bands of ironstone		19 0
	Dip 20°.		
46.	Carbonaceous shales, with impure ironstones		14 0
47.	False bedded fine grained sandstone		
	Coal with dyke passing through (seam reversed)		0 6
	Dips E. by S.		

The succeeding beds, after a short distance down, dip once more to the north-west, and are chiefly sandstones.

We have in this section an aggregate of 60 feet of coal seams, rendered nearly useless by their high inclination. The lowest dip is 18° and it gradually increases until it becomes as much as 70°.

The quality of the coal is inferior. The best seams are Nos. 9, 19, and 25, but they contain a considerable amount of ash and especially iron.

The only other coal that was discovered on this side of the Damoodah, was one seam near Bhonra, and two others in a tributary nullah of the Kunjeea Joor.

South of the Damoodah coal occurs only in one nullah to the north-west of Umlabad. Several thin seams, all under 6 inches in thickness, are seen dipping at 20°. The largest is one just south of Ranatand, 1 foot 6 inches. A hundred yards lower down the course of the nullah a slight change takes place in the strike, and the dip becomes west-south-west 25°. A seam occurs dipping in this direction, and also to the north at an excessively high angle. A little stream joins the main one at this spot, flowing from the west, and in it the beds visible are all greatly inclined. Below this, the dip is due west 15°, and then comes a dyke coursing east and west. It has spread over one of the beds of sandstones, hardening it into a quartzite; most of it is now worn away.

Coal at Ranatand.

South of Talgurreea, the ground generally is covered over by alluvium, so that the boundaries and the strikes of the rocks are not seen.

Talgurreea.

No more coal has as yet been discovered in the Barákar series beyond the seams enumerated in the foregoing pages. A section has been given of every river or little stream that flows through the coal measures, and I think from the mass of detail gathered together that not a single bed of coal has escaped detection. The continuation of most of the seams could not be traced out, as the ground intermediate between the several rivers is usually so covered up either by alluvium, grass, or paddy fields that nothing definite could be made out regarding them. Several

seams are recognisable by their black mud outcrops, but nothing further; and their position is indicated by description in the report instead of being mapped.

Summing up the whole of the sections, and drawing our conclusions from them, we find that, although they differ in detail, the general result is the same. The quantity of actual coal is probably 80 to 100 feet, where the series is fully developed. But the quantity available is less, varying, of course, according to the thickness of each seam and its freedom from partings. The habit of the seams is the same in all the rivers, the larger ones being confined to the bottom, and decreasing in size as they ascend in the series.

Fossil flora.

The fossils obtained from the Barákars belong entirely to the vegetable kingdom, and although numerous individually, are few generically and specifically. The state of preservation of many of them is excellent, and some of the ferns, which, as a family, resist well the decomposing action of water and other agencies, retain their spores. The plants composing the Barákar flora belong mainly to the two genera, *Vertebraria* and *Glossopteris*, and they are found at all horizons, being more numerous, however, at the top than at the bottom. Trunks of trees are also to be met with.

Not a single animal remain occurs, although shales are so plentiful.

Dykes.—All the three groups of the Damúda rocks are penetrated by trap; but from the evidence of the numerous seams of coal injured its action appears to have been more violent in the lower.

(*b*.) Carbonaceous shales with ironstones.—There is very little to say about this group further than that, although not so well represented as it is in the Ráníganj Field, it is the equivalent of the ironstone-shales of that district. They are best represented in the Khodo and Kuttree Nuddees, where they are about 600 feet thick, but nowhere are there indications of their presence at the surface like those seen in the vicinity of the Barákar River in the Ráníganj area. In the Jummoonee they are represented by thin argillaceous shales and sandstones, the latter assimilating the character of the series nearest to which they occur.

Best seen in the Kuttree.

The quality of the ironstones is very poor, and they are so siliceous that even the native Kummars can do nothing with them.

Mr. Smith, during his examination of the different localities in Bengal, where iron-ores were known to exist, passes over the Jherria Field, with only a few remarks, asserting that it contained no ore fit for smelting purposes; an opinion that has been confirmed by more detailed examination on the part of this survey.

(*c.*) RANIGANJ GROUP.—It is not until the whole survey of the field has been completed that the difficulty of drawing the distinction between the several groups of the Damúda series can be duly appreciated. In the absence of a well marked lithological horizon, such as was afforded by the carbonaceous shales with ironstones in the Ŕániganj Field, this is peculiarly the case; and the only guide which would have afforded a means of overcoming the difficulty was palæontological evidence; but this could seldom be obtained, and therefore little dependence could be placed upon the testimony of fossils, even when found, as to whether we had the lowest, middle, or top beds of the group of which they were characteristic.

General parallelism.

A general parallelism exists between the Barákar, the Carbonaceous shales, and the Ŕániganj groups, so that no great period of rest and upheaval of the one previous to the deposition of the other could have taken place; and from the observations made in this district, it seems most likely that the entire Damúda series was deposited continuously without any appreciable break in time. Wherever the groups are seen in contact, there is a similarity in strike and amount of dip; and the beds of the one pass into the other.

Flora.

The Ŕániganj flora embraces a longer list than the Barákar, and there are some forms of leaves quite distinct, and which are not found in the latter series. The *Schizoneura* is always characteristic of the upper portion of the Damúda series and is an excellent test for determining the approximate horizon of the beds in which it is found. Another quite as characteristic is *Tæniopteris Danæoides*, a broad leafed fern, but this is seldom found. The less important genera are *Phyllotheca, Vertebraria, Pecopteris, Glossopteris*, and (?) *Poacites*.

Distribution of the group.

The group is about equally distributed on both sides of the Damoodah. To the south of the river the dips are usually high, and in a northerly direction. Local rolling is frequent, and about the vicinity of Purbutpoor we find the beds dipping both north and south. Near Aloaca they twist round to the west. Near the great fault the strata are nearly vertical, but quickly decrease to about 30° or 35°. The most prominent beds are false-bedded micaceous sandstones, and the slightly calcareous rock which has so frequently been alluded to. Pebbles are found in many of the beds, but not to the same extent as they are in the Barákars.

The only localities in which coal of this group is found, are the left bank of the Damoodah, in the Kutras Pergunnah, the Jummoonee, and a tributary of it, the Mudhoobun Nullah.

Leaving the Damoodah Section until the last, the following is that of the Mudhoobun River.

The first seam is seen at its junction with the Jamdeeha Nullah:—

		Ft.	In.
1.	*Coal* seam	8	6
2.	The next one, a few feet higher in the series, is destroyed by trap ..		
3.	Sandy, micaceous, slightly carbonaceous shales	55	0
	Dip 35°		
4.	*Coal*	3	0
5.	Ironstone and carbonaceous shale	1	7
6.	Carbonaceous shales and yellow sandstones; also sandy siliceous shales	76	0
7.	Carbonaceous shales, with a thin seam of coal at top	3	6
8.	Sandy shales and yellow sandstone	28	0
9.	Carbonaceous shale	2	0
10.	*Coal* seam	3	5

	Ft.	In.
Coal...	1	2
Clay shale		2
Coal (inferior)	1	0
Ironstone		1
Coal (inferior)	1	0
Total of *coal*	3	2

		Ft.	In.
11.	Carbonaceous shale, with one run of ironstone	14	0
12.	Yellow sandstone	3	0
13.	Siliceous sandstone, angle of dip 25°	10	0

		Ft.	In.
14.	*Coal*, inferior, and much mixed with shale	3	9
15.	Chiefly yellow siliceous sandstones containing carbon; also carbonaceous and sandy micaceous shales	59	0
16.	*Coal*, inferior and shaly	1	2
17.	Fine grained compact purplish micaceous slightly carbonaceous sandstones. Dip 35°	57	0
18.	*Coal* seam	4	4

	Ft.	In.
Coal	2	0
Ironstone shale		1
Coal	2	3
Total of *coal*	4	3

		Ft.	In.
19.	Carbonaceous shales	28	0
20.	Chiefly variegated red, white, and black sandstones	198	0
21.	*Coal*	1	0
22.	Sandstone, thick and false bedded; also shales	64	0
23.	Ordinary grey sandstones containing quartz pebbles	30	0
24.	*Coal* seam	7	2

	Ft.	In.
Coal	1	4
Fine siliceo-carbonaceous shale	1	10
Coal (fair)	4	0
Total of *coal*	5	4

25. White siliceo-micaceous sandstones, with yellow calcareous sandstones

No further section is seen from this down to its junction with the Jummoonee.

None of the coal seams above enumerated are of any value; their dips speak for themselves, and even if these were low and favorable, the quality of the coal itself is inferior. The best seam is No. 24.

Section of the Jummoonee.—In the Jummoonee the lowest beds are well seen, and the section, after the finely laminated argillaceous shales of the middle series, is—

		Ft.	In.
1.	Hard felspathic calcareous sandstone. Dip 40°	32	0
2.	Argillaceous shales containing a small quantity of carbonaceous matter. Dip 35°...	63	0
3.	*Coal*		8
4.	Argillaceous shales cut by a small dyke. Dip 35°	40	0
5.	Argillaceous shales above dyke	17	0
6.	*Coal* affected slightly by trap	2	0
7.	Carbonaceous shale and ironstone	1	0
8.	Sandy shale with carbonaceous matter	21	0
9.	Yellow sandstone	2	6

		Ft.	In.
10.	Silicco-micaceous shales containing iron	60	0
11.	*Coal* seam. Dip 35°	6	2

	Ft.	In.
Coal		8
Carbonaceous shales ...	1	0
Coal	4	6
Total of *coal*	5	2

12.	Argillaceous shales, with concretionary structure and yellow sandstones...	69	0
13.	*Coal* seam	9	0
14.	Sandy micaceous shales containing carbonaceous matter ...	34	0
15.	Yellow sandstone and brown sandy shale	14	0
16.	*Coal* seam	3	8
17.	Sandstones, greenish tinged	65	0
18.	Shales of variegated colours	13	0
19.	Coaly shale and inferior coal	10	0
20.	Shales with yellow slightly calcareous sandstone	11	0
21.	*Coal.* Dip 30°	1	6
22.	Sandy shales, with a thin seam of coal	75	0
23.	Calcareous yellow sandstone	1	6
24.	Slightly calcareous, micaceous, and sandy shales	15	0
25.	Thin seam of coal		8

Dip E. S. E. by S.

26.	Sandstones and argillo-micaceous shales	65	0
27.	*Coal* at corner of river	3	0
28.	Thin bedded sandstones and shales, the latter somewhat carbonaceous	165	0
29.	Massive sandstones containing pebbles; also very thinly-bedded sand-Stones; a greenish tinge prevalent	171	0
30.	*Coal* seam, small, in which iron in a pisolitic form is visible ...	151	0
31.	Shales	2	4
32.	*Coal*		
33.	Intermediate beds	37	0
34.	Coaly shale, thin		
35	Sandstones and shales	91	0
36.	Coaly shale	1	2
	Junction of the right bank of the Mudhoobun and the left bank of the Jummoonee.		

Dyke.

37.	Massive white felspathic sandstones, the upper portion slightly carbonaceous	225	0
38.	Carbonaceous shales containing plants (in these beds a *Schizoneura* was obtained)	12	6
39.	Sandstones	37	6

Dip changes from due S. to S. by W.

40.	Carbonaceous shales and sandstones, the latter predominating ...	109	0
41.	*Coal* (inferior). Dip 25°	3	0
42.	Chiefly massive sandstones and sandy brown shales colored partially by carbonaceous matter. Dip 25°	210	0
43.	Greenish highly micaceous silicoo-argillaceous sandstones containing a small quantity of lime	440	0

Dyke from Mudhoobun.

Below this the beds are reversed, dipping N. W. by N.

Only two beds of coaly shale are imperfectly seen before the Jummoonee falls into the Damoodah. Metamorphic rocks are brought up at its mouth.

In this section the Raniganj beds are better seen than in any other; they have a total thickness of about 2,300 feet, and an aggregate amount of about 35 feet of coal seams. None of the seams appear of any value, and as only five of them are 3 feet thick and upwards, it is at once seen that the amount of available coal that they can contain must be very small. The 3 feet seams could not pay, even if the dip was favorable, and considering that the lowest angle at which they dip is 25° they may at once be dismissed as useless. The 9 and 10 feet seams dip as much as 35° so that it can safely be stated that not one of the seams in the above section is at present of any value.

The same remarks in a modified degree apply to the seams seen in the Damoodah.

The rocks exposed at the surface about Kundra and Koonjee are false-bedded sandstones, and fine grained white siliceous shales with bands of yellow calcareous sandstones dipping at angles of 15°, 18°, and 20° to south by west. Near Telmuchio they are nearly horizontal, an axial line of flexure passing through it, the beds north of this dipping S. S. E. and those south of it dipping N. W. by N.

The green sandstones (No. 43) of the Jummoonee section are continuous on both sides of that river. They resemble very much some of the Panchet sandstones in the Raniganj field. No coal is observed anywhere on the high land north of the Damoodah, except in one place in the Bugdiggee River south of Singra. It is small and obscure.

Damoodah Section, from bottom to top,

The lowest seam occurs south of Moorleedeeh, and the section is—

		Ft.	In.
1.	*Coal* imperfectly seen	2	6
2.	Greenish argillaceous shales, with inferior ironstones	6	0
3.	Brownish green arenaceous shales, and beds similar to No. 2 ...	13	0
4.	Yellow calcareous sandstones		8
5.	Like No. 3	2	6
6.	Carbonaceous shales	1	6
7.	Brownish green micaceo-arenaceous shales	8	0
8.	Coaly shales		7
9.	Brownish green shales, and yellowish false-bedded sandstones ...	38	0
10.	Coaly shales		9
11.	Yellowish false-bedded sandstones and shales similar to those before mentioned	17	0
12.	*Coal*	1	10
13.	Yellow slightly calcareous sandstone	8	0
14.	*Coal* seam	5	7

	Ft.	In.
Coal	4	10
Parting		4
Coal		5
Total of *coal* ..	5	3

		Ft.	In.
15.	Sandstone and argillaceous shales	8	4
16.	Carbonaceous shale		5
17.	Areno-argillaceous shales	9	0
	These shales further West decrease to 3 7 and finally to 1 10.		
18.	*Coal* seam	6	11

	Ft.	In.
Coal	5	4
Carbonaceous shale ...		3
Coal	1	4
Total of *coal* ...	6	8

		Ft.	In.
19.	Argillaceous shale	3	1
20.	*Coal*	1	2 to 12
21.	Argillaceous shale	4	8
22.	*Coal* dies out		

The Jewgurba here unites with the Damoodah, and at its mouth there is a small waterfall, by which it can easily be recognised. At the base of the fall, No. 18 seam is seen; and above it two small ones, and then sandstones containing pebbles: No. 18 shows along the bank for some way, and then turns inland. Opposite Khuddum Ghat, where a large tree stands in the bed of the river, No. 14 seam reappears. A little west of two tamarind trees further up the stream No. 18 again shows. Going still west No. 12 is seen 1 foot 8 inches thick instead of 1 foot 10 inches; above this we have peculiarly well defined yellow arenaceous

sandstone slightly calcareous, which cannot fail to strike the observer as being identical with that seen further east. Seams No. 14 and 18 appear again, and then the section is—

		Ft. In.	Ft. In.
	Arenaceous shale corresponding to No. 19	2 3	
	Coaly shale, or inferior coal, corresponding to No. 20 ...	1 1	
	Slightly concretionary carbo-arenaceous thin bedded sandstones, including Nos. 21 and 22		58 0
24.	Greenish grey argillaceous shale		2 10
25.	Carbonaceous shale and coal		9
26.	Argillaceous and micaceous shales with yellow sandstones ...		19 0
27.	*Coal*		4
28.	Shales (about)		5 0
29.	*Coal* imperfectly seen		
30.	Argillaceous shale		2 6
31.	Extremely false-bedded sandstone		10 0
32.	Thin-bedded arenaceous sandstone		3 0
33.	Yellow, thin false-bedded arenaceous sandstone		11 0
34.	*Coal* seam		3 11

	Ft. In.	
Coal	1 6	
Argillaceous parting ...	1 2	
Coal	1 3	
Total of *coal*		2 9

35.	Carbo. argillaceous shale	5
36.	Arenaceous sandstone	3 9
37.	Coaly shale	10
38.	Areno-argillaceous shale	7 0
39.	Sandstone	17 0
40.	Thin bedded sandstone and shale	11 0
41.	Coaly shale	1 0

West of this the sand is silted up against the banks, and the river is greatly obscured for some distance; whitish fine-grained sandstones are the principal rocks to be seen. The next seam occurs south of Parjoree; it is injured by trap. Dip 27° W. N. W. It can be traced to the Mudhoodeeh Nullah, and its section, where worked by the villagers, is—

	Ft. In.		
Coal seam. Dip 20°			8 0
Coal	3 0		
Slaty parting	1 0		
Coal	4 0		
Total of *coal*		7 0	

Below this is a 4 feet seam not seen in the Damoodah.

The next coal in the Damoodah above the 8 feet one, is a seam measuring 6 feet and dipping W. N. W. at 27°—

This is the last that shows, and is the highest in the series: massive, fine grained sandstones with a greenish tinge occupying the rest of the section to the fault.*

South of the Damoodah no coal shows at the surface; some might be met with on boring, but owing to the vicinity of the large southern fault, the beds would be too much contorted, and too highly inclined to be of any use.

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* *East of Jaytureea.*—The Jewgurba contains three small seams not seen in the Damoodah, measuring, respectively, 2 feet 7 inches, 3 feet, and 1 foot. The dip is 18°.

Another section is shown in the stream flowing from the tank near Moorleedeeh, about 300 yeards north of the Damoodah. Three seams occur :—

		Ft. In.	
The lowest one is	... ...	... 1 0	
	Shales ...	... 4 0	
	Coal... ...	5 to 3 0	
	Intermediate beds and then		
	Coal seam ...	... 9 2	
	Coal ...	...	6 8
	Parting ...	...	2
	Coal ...	...	2 4
	Total of *Coal*	...	... 9 0

FAULTS AND DYKES.

Faults have not been proved to be so numerous as they usually are in most coal fields, but doubtless there are many more than those indicated upon the map, or even mentioned in the body of the report. The difficulty of making out the entire system will always exist, until greater facilities are afforded by mining operations, railway cuttings, and such like works, for examining the rocks more closely, and obtaining a more intimate knowledge of their relations to each other. At present, therefore, we must content ourselves with the imperfect results that the absence of any such facilities entails, and leave for the future geologist the task of fully and satisfactorily working out the series of dislocations by which this field is intersected.

Southern fault.

The largest fault that has been determined is one cutting off the whole of the coal measures to the south, and forming the southern boundary of the field. It passes north of Booray Serra, and runs for some way in the bed of the Damoodah, then north of Koomhurree and Batbinor; through Ooparbundah and Mahal, south of Goondleebheeta, and then turns slightly northwards towards Bhojoodeeh, leaving the field soon after to pass through exclusively metamorphic rocks.

It has a maximum throw of between 3 and 4,000 feet, and is very clearly marked throughout almost its whole course by a small ridge that stands up above the level of the gneiss country, so that no difficulty is experienced in tracing it. Beyond the field, however, it is at once lost sight of, not being distinguishable by any physical feature; in this respect resembling the southern fault of the Raneegunj Field.

The district west of the Jummoonee is the area that has been subjected to the greatest amount of disturbance, and the faults there are better seen than elsewhere. It is useless to specialise or give any lengthened description of them, as they at once readily explain themselves on an inspection of the map.

East of the Jummoonee the faults are very obscure, and indeed only visible when they displace such prominent rocks as coal or carbonaceous shale. They are mentioned in the body of the report, but are all too small to be inserted on the map.

Dykes.—Trap dykes of all sizes, varying from 60 feet broad to 1 foot, occur abundantly both in the Talchir, and the Damúda series. The more abundant minerals entering into the composition of the trap are augite, felspar, and mica; and olivine and iron pyrites in smaller proportions. The texture is usually compact, and the crystals are small. Owing to variations in condition of pressure, we find in the same dyke, along different portions of its course, the rock passing from an augitic to a hornblendic trap. And it would be most difficult in a hand specimen to say whether many of the dykes were basalts or greenstones.

Besides the distinctive basalts however, that is, dykes in which the texture is compact, and augite wholly replaces or is in excess of hornblende, there are others containing large quantities of mica, always more or less decomposed, of a yellowish color. These dykes never are very broad.

They follow no general course, and therefore do not help in any way to indicate their age relatively to the other trap intrusions of the district.

Foreign to the trap, pieces of gneiss are occasionally entangled in it, showing that the seat of volcanic action is situated in some horizon lower than the coal measures themselves.

The greater frequency of trap dykes in the coal rocks, as compared to those in the gneiss, cannot fail to attract the attention of most observers. Why such is the fact is not easily explained, but it is probably due to the greater fissility of the Talchirs and Damúdas, so that what would remain as one fissure in the gneiss possibly splits up into three or four

in the sedimentary series. Most of these multiplications would be more or less parallel in direction, and would die out much sooner than the great prime fissure of the gneiss, and thus the sudden manner in which several nearly parallel dykes become pinched out, whilst one continues steadily holding its course may be accounted for. The example in view, as illustrative of this suggestion, is the one near Jogeedeeh, where three large dykes occur, of which only one continues to hold steadily for some miles, whilst the other two die out at comparatively short distances.

The strongest runs have a north-easterly course; the secondary set a north-westerly one,—directions which they assumed on account of pre-existing fissures; none of the dykes observed having burst through the rocks.

The data for establishing the relative ages of these two groups are as yet too imperfect to state anything positively. Facts, however, are being collected from further and more extended observations in other districts, and it is hoped that when the chain of coal-fields extending up the valley of the Damoodah and along its parallel have been thoroughly examined, they will afford such a mass of cumulative evidence that sound and reliable generalisations can be founded on them.

In addition to actual trap dykes there are many hardened ridges, the results of trappean action. They have a pretty constant east and west run, and the best examples are those in the east of the field near Jorapokhur and Bhoura; and one north of Menjina in the west. They consist for the most part of sandstones. In some cases they exhibit columnar structure—the ridge south of Jorapokhur is the best instance. No trap is now usually found associated with them, it having been all removed either by decomposition or denudation. A trace, however, is seen associated with the Menjina ridge, and it confirms the inference, which, nevertheless, could never have been doubted, that trappean action originated these ridges.

ECONOMIC SUMMARY.

It has been shown in the preceding pages that, with the exception of the middle series, coal is found at all depths in the Damúda series. The larger seams generally being at the base, while those occurring at the top are smaller.

Coal found at all depths.

The excellence of the coal in the Raniganj group of the Raneegunj Field is well known, but in the Jherria District, although there are many seams in the upper series superior to some in the Barakurs, the finest coal and the freest from ash occurs in the latter. In the Kurhurballee Field, 28 to 30 miles north of the Jherria Field, now described, much of the coal, there exclusively of Barákar age, is superior to that of other districts; some of it yielding on assay as small an amount of ash as 2·5 and 4 per cent. Coking coal, as far as experiments have yet been made, is found only there; and the evidence both in that and the present field tends to show that, whatever the average superiority of the coals of the Raniganj group over those of the Barákars may be, the best quality of coal is found amongst the latter.

Best coal occurs in the Barákar group.

In making a comparison of the economic values of the two series in this field, it must be remembered that, in addition to the comparative sizes of the seams, their freedom from partings, and their constancy, the question of the amount of dip enters largely into the subject. In India, where appliances for working collieries are necessarily limited, and human labour is, in many cases, the only power available, a slight increase in the angle of inclination would necessitate such an addition to the expenditure, owing to the greater depth from which the water would have to be pumped out and the coal raised, that whereas a seam dipping at 12° and 15° might profitably be worked, one inclined at 20° or even 18° would have to be abandoned, unless its superior quality enabled it to fetch a greater price in the market.

Bearing this in mind, then, it is evident from what has been stated in this report, that seams in the Barákar group have the great advantage over those in the Ranieganj series of dipping at much smaller angles, thus affording greater facilities for being worked. Indeed the inclination throughout the Raniganj group is so high that its economic value may be set down as being nearly nil,* and we need only summarise the seams of the Barákar group, and point out the most favorable portions of the field in which they occur.

The following is a summary of the seams that have been noticed in each of the principal sections, showing in different columns the actual or apparent sizes of the seams seen, the actual or apparent quantity of coal contained in them, the available amount, and the dip of the bed ;—

Chutkurree Joor.

No. of seam.	Thickness of Seam.		Thickness of Coal.		Available thickness.	Quality.	Dip.	Trap.
	Apparent.	Actual.	Apparent.	Actual.				
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.			
1st Seam ...	......	50 0	......	......	......	......	6° to 7°	...
2nd „ ...	......	6 0	......	......	......	Poor	......	...
3rd „ ...	......	9 0	......	......	......	Good	6° to 10°	Trap.
4th „ ...	......	1 0	......	......	......	......	......	...
5th „ ...	......	4 8	......	4 4	4 4	Good	......	...
6th „ ...	......	8 8	......	7 6	......	Poor	7°	...
7th „ ...	13 0	......	......	......	......	Middling	5° to 7°	...
Total ...	13 0	79 4	......	11 10	4 4			

* Of course when the Barákar group are exhausted those of this series will become valuable, but not until then.

Kurree Joor.

No. of seam.	Thickness of Seam.		Thickness of Coal.		Available thickness.	Quality.	Dip.	Trap.
	Apparent.	Actual.	Apparent.	Actual.				
1st Seam ...	......	3 0	......	......	......	Poor	12°	...
2nd & 3rd Seams ...	......	......	......	......	......	Poor	......	...
4th Seam ...	......	......	......	......	......	Poor	10°	...
5th „ ...	......	5 0	......	......	......	Poor	......	...
6th Nayadeeh ...	......	17 10	......	13 2	6 10	Mixed	......	...
[illegible] „ ...	......	8	......	8	......	......	......	...
[illegible]th „ ...	20 0	......	......	......	......	......	......	Trap.
9th Koosoonda ...	......	15 0	15 0	......	8 0	Good	8°	Trap.
10th „ ...	......	......	......	......	......	......	......	Trap.
11th „ ...	......	1 6	......	......	......	......	......	...
12th „ ...	......	3 7	......	3 2	......	Poor	7°	...
13th Koostur ...	10 0	9 7	......	9 2	9 2	Good	10°	...
14th Baghaband ...	10 0	......	......	......	......	Middling	10° & 12°	...
15th „ ...	......	......	......	......	......	......	......	Trap.
16th „ ...	......	1 6	......	1 0	......	......	......	...
Total ...	40 0	57 8	15 0	27 2	24 0			

The above two sections are rather imperfect. Still it appears that 24 feet of coal is available, the actual and apparent amount being probably double that shown in the summary. It must be remembered that these figures only pretend to give the results which have been arrived at by myself, as well as the difficulties under which I laboured would allow. Many of the seams contain available coal, although from the absence of all workings and sections, I was not able to see it, and the total amount in a section is always greater than is shown in the table, as I merely give the thicknesses that I actually saw and measured.

Busraya Nullah.

No. in Section.	Thickness of Seam.		Thickness of Coal.		Available thickness.	Quality.	Dip.	Trap.
	Apparent.	Actual.	Apparent.	Actual.				
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.			
7	......	2 0	......	2 0	......	Poor	15°	
11	8 0	......	......	......	......	......	......	
15	......	11 4	......	4 2	......	......	......	
21	38 0	......	......	......	......	......	10°	
23	18 0	......	......	......	......	......	......	
25	......	1 1	......	1 1	......	......	......	
27	......	1 0	......	11	......	......	......	
33	3 0	......	......	......	......	......	......	
41	21 0	8 6	......	8 2	8 2	Fair	15°	
48	22 0	......	......	......	......	Fair	4°	Trap.
49	......	1 0	......	1 0	......	......	......	
54	......	4 6	......	3 9	3 9	Good	......	
56	......	3 8	......	3 8	3 8	......	......	
58	......	1 9	......	1 5	......	......	5°	
62	......	5 0	......	4 4	4 4	Good	......	
66	......	11 3	......	6 6	4 2	Fair	......	
69	......	1 5	......	0 10	......	......	......	
Total ...	119 0	52 6	......	37 10	24 1	......	......	

Busjooreea.

8	......	2 0	......	......	......	......	......	
14	......	1 2	......	......	......	......	15°	
16	38 0	......	......	......	......	......	15°	
19	......	5 2	......	......	......	......	......	
23	......	2 0	......	......	......	......	......	
27	......	1 0	......	1 0	......	......	10°	
40	......	1 8	......	......	......	......	10°	
45	12 0	......	......	......	......	......	......	
48	......	12 5	......	......	......	Middling	15°	
51	......	91 10	......	56 4	56 0	Good	12° to 20°	
56	......	2 4	......	2 4	......	......	30°	
72	......	1 5	......	0 10	......	......	18°	
77	......	12 6	......	......	......	......	21°	
79	......	2 6	......	2 8	......	......	......	
83	......	9 10	......	9 2	......	......	......	
85	......	32 0	......	......	......	Fair	......	
89	......	10 0	......	......	......	......	16°	
91	......	8 0	......	......	......	......	12°	
95	......	2 0	......	......	......	......	......	
118	......	10 6	......	8 6	8 6	Good	......	
120	......	3 0	......	......	......	Inferior	......	
124	......	1 1	......	......	......	......	......	
Total ...	50 0	212 5	......	80 5	64 6	......	......	

Kuttree (the seams under 1 foot are left out).

No. in Section.	Thickness of Seam.		Thickness of Coal.		Available thickness.	Quality.	Dip.	Trap.
	Apparent.	Actual.	Apparent.	Actual.				
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.			
4	......	2 0	......	......	......	Poor	14°	
6	......	22 0	......	14 0	14 0	Fair.	...	
14	......	7 11	......	6 10	5 4	......	...	
20	......	2 0	......	2 0	......	Poor	...	
22	......	16 2	......	14 2	......	Poor	10°	
30	......	2 8	......	2 8	......	Poor	...	
33	......	2 0	......	2 0	......	......	...	
40	64 0	......	......	......	......	Fair	...	
45	......	6 2	......	5 6	5 6	Good	...	
48	......	6 7	......	6 6	6 6	Good	...	
52	......	3 8	......	2 6	......	......	...	
66	......	5 9	5 9	......	......	......	8°	
72	......	3 4	......	3 2	......	......	15°	
75	......	1 0	......	1 0	......		17°	
77	......	1 6	......	......	......	......	...	
Total...	64 0	81 9	5 9	61 4	31 4			

Bugdiggee.

No. in Section.	Seam Apparent.	Seam Actual.	Coal Apparent.	Coal Actual.	Available thickness.	Quality.	Dip.	Trap.
1	......	2 6	......	2 5	......	Good	7°	
8	4 0	......	......	......	......	......	...	
10	8 4	......	7 7	......	......	Good	8°	
12	......	6 10	......	6 10	6 10	Superior	10°	
18	2 0	......	......	......	......	......	...	
21	......	2 7	......	1 7	......	......	10°	
25	......	7 2	......	6 10	6 10	Mixed	10°	
36	15 0	......	15 0	......	......	Good	...	
41	......	3 9	......	1 9	......	Poor	...	
45	......	3 10	......	2 10	3 10	Poor	...	
48	......	5 8	......	5 0	5 0	......	10°	
51	......	5 2	......	4 8	4 8	Mixed	...	
59	......	1 1	......	1 1	......	Poor	13°	
74	......	3 5	......	3 0	......	Good	...	
77	......	1 1	......	1 1	......	......	...	
81	......	1 0	......	1 0	......	......	...	
92	......	4 9	......	4 0	......	Poor	...	
101	......	8 10	......	4 4	......	Mixed	...	
103	......	5 0	......	4 6	4 6	Fair	15°	
110	......	2 0	......	2 0	......	......	...	
Total...	29 4	64 8	22 7	53 11	51 8			

Khodo.

No. in Section.	Thickness of Seam.		Thickness of Coal.		Available thickness.	Quality.	Dip.	Trap.
	Apparent.	Actual.	Apparent.	Actual.				
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.			
3	60 0	......	......	......	......	Poor	7° to 10°	Trap.
7	8 0	......	......	......	......	......	7°	...
9	......	2 0	......	2 0	......	Inferior	......	...
Toondo Seam	......	......	......	......	......	Fair	5°	Trap.
11	7 10	......	......	5 10	......	Mixed	......	...
17	......	1 2	......	1 10	......	......	......	...
20	......	1 6	......	1 6	......	......	30°	...
22	......	4 2	......	4 2	......	Poor	30 to 40°	...
24	......	1 0	......	1 0	......	Poor	30° to 32°	...
26	......	2 6	......	2 6	......	......	30°	...
28	......	3 0	......	3 0	......	......	......	...
30	......	10 0	......	......	......	Poor	35°	...
32	......	2 8	......	2 4	......	......	......	...
36	......	1 0	......	1 0	......	Inferior	35°	...
40	......	6 10	......	4 10	......	Poor	28°	...
45	......	4 0	......	4 0	......	......	22°	...
55	......	1 4	......	1 4	......	......	15°	...
62	......	1 0	......	1 0	......	......	......	Trap.
64	......	5 0	......	3 0	......	......	15°	Trap.
66	......	4 5	......	2 11	......	Mixed	......	...
68	......	2 2	......	1 8	......	......	......	...
72	......	6 4	......	3 8 to 4 4	4 0	Good	......	...
76	......	2 0	......	2 0	......	......	......	...
78	......	3 2	......	2 6	......	......	......	...
105	......	1 1	......	10	......	......	......	...
	70 10	66 4		53 7	4 0			

In this section there is scarcely any available coal, the thickness of the coal in the respective seams being far too small to pay a colliery worked on Indian principles. No. 3, the Toondo seam, and No. 72, are the only seams at all likely to be available. Those between Nos. 20 and 40 dip at too high angles.

Mudhoobun Nullah.

No. in Section.	Thickness of Seam.		Thickness of Coal.		Available thickness.	Quality.	Dip.	Trap.
	Apparent.	Actual.	Apparent.	Actual.				
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.			
1	....	5 1	....	4 5	4 5	Mixed	10°	..
5	....	2 6	....	2 6	....	Good	....	..
7	....	8 5	....	6 0	....	....	....	Trap.
(a)	....	5 6	......	4 10	....	....	...	..
(c)	..	1 0	....	1 0	....	.....	17°	..
(e)	....	5 6	....	5 6	....	.....	....	..
(g)	....	3 3	....	2 1	....	...	15°	..
..	....	2 6	....	....	....	....	....	..
..	....	7 0	....	....	....	....	25°	..
..	....	5 0	....	....	....	....	25°	..
Total	....	45 9		26 4	4 5			

Jummoonee Nuddee.

No. in Section.	Seam Apparent.	Seam Actual.	Coal Apparent.	Coal Actual.	Available thickness.	Quality.	Dip.	Trap.
7	....	1 0	....	1 0	....	....	....	..
17	....	6 0	....	6 0	....	Inferior	....	..
20	....	1 0	....	1 0	....	....	....	..
25	....	9 0	....	7 0	....	Mixed	6°	..
27	126 0	....	....	....	....	Very inferior	10° 40'	..
29	....	7 7	....	7 0	....	Mixed	....	..
34	....	18 6	....	....	....	Poor	10°	..
37	....	21 6	16 0	....	16 0	Middling	8°	..
42	....	10 0	....	10 0	10 0	Fair	10°	..
44	....	1 9	....	....	....	....	....	..
47	....	11 0	9 0	....	....	Poor	....	Trap.
59	....	5 9	....	....	....	Inferior	22° to 23°	..
62	....	5 6	....	4 6	....	Poor	....	..
69	....	....	....	....	....	....	....	Trap.
73	....	7 10	7 10	....	....	Fair	22°	..
75	....	1 0	....	1 0	....	....	....	Trap.
77	....	12 0	12 0	....	....	....	....	Trap.
79	....	3 0	3 0	....	....	....	22°	..
85	....	4 0	....	4 0	....	Good	30°	..
91	....	3 3	....	2 11	....	....	....	..
95	.....	1 4	....	1 4	....	....	....	Trap.
99	....	2 2	....	2 2	....	....	....	..
100	100 0	....	17 7	....	....	Mixed	....	Trap.
103	....	....	....	....	....	....	....	Trap.
104	....	1 0	....	1 0	....	Inferior	30°	..
106	....	2 0	....	2 0	....	....	....	..
111	....	....	....	....	....	....	....	Trap.
113	....	....	....	....	....	....	....	Trap.
Total ..	226 0	136 2	65 5	50 11	26 0			

List of burnt seams not mentioned in the river sections.

Village.	Position.	REMARKS.
Godhur.	North of village.	
Jeenagurha.	West of village.	
Jairamdeeh.	South of village.	Two seams.
Jherria.	East and north-east of village.	Two seams occur.
Kendwadeeh.	South of village.	Some of the houses are buil on it. Trap occurs with the clinker.
Koosoonda.	North-west of village.	Two burnt seams, each with trap.
Lodana	West of village.	This is a strong ridge.
Mudhoobun	North of village.	
Mutteegurha	Village built on it.	
Sootukdeeh	North of village.	Accompanied by trap.

From a comparison of the above summaries the conclusion to be drawn is that, as far as the actual thickness of coal is concerned, it is equably distributed over the field; but that the greatest available thickness occurs in the eastern portion. The Chutkurree, the Kurree, the Busraya, Busjooreea and Kuttree, contain the largest number of workable seams. Their dips are usually favourable, and the average quality of the coal is superior to that occurring in the other parts of the field.

To judge correctly, however, of the relative value of the coals exposed in each section, and to make positive statements, far more opportunities for actually testing the quality of the coal extracted from some depth below the surface are required, than were open to myself.

The best coal from this field contains about 3 to 4 per cent. of ash, and from this the amount ranges up to 30 per cent. The ordinary quantity is 11 per cent. The quality depends entirely upon the proportion between the dull and the fatty laminæ composing the coal, the preponderance of the latter raising the standard of the coal, while that of the former depresses it. Some assays made to determine the percentage of ash in the fatty layers gave a range of 7 to 1·5 per cent., while the volatile matter and fixed carbon ranged from—the former 37 to 40 per cent., the latter 58 to 62 per cent.

Iron Ores.—The entire district is, with the exception of one spot, barren with respect to iron ores. East of Budkhurma some extremely ferruginous concretions in red micaceous clay shale are employed in a furnace standing near Teelaya. The manufacture of iron has, however, now been abandoned in the district, owing to the scarcity both of ore and wood, and it is only in the district of Hazareebagh, that the native workman is to be seen smelting iron, in his primitive earth furnaces of about 2 to 3 feet high.

Limestone—is not plentiful; the only supply that could be obtained would be from the Talchirs, but this would be too small in quantity, and too irregular in composition, to be made available in any large operations. Enough for the ordinary wants of the natives is obtained from the kunkur that occurs in various places throughout the field.

Building and flooring stones.—In the Talchirs, many of the sandstones are capable of being made into excellent flooring stones. In the barracks at Hazareebagh all the rooms are paved with them. The Barákar group yields, as may be seen at the bridge over the river of that name, to the west of the field now described, excellent building stones.

Note on the JHERRIA COAL-FIELD, *by* T. OLDHAM, *Supt. of the Geological Survey of India.*

JHERRIA OR JHERRIAGURH, from which the coal-field described in the preceding pages has been named, was noticed in one of the earliest descriptive papers of the coal-fields of India. This paper by Mr. Jones appeared in the XVIIIth Volume of the *Asiatic Researches*, and although only published in 1829, was probably written about the time when Mr. Jones was actually engaged in working the collieries referred to. The paper is entitled, 'Description of the North-West Coal District, stretching along the river Damoodah from the neighbourhood of Jerria or Jurriagerh, &c., &c.' The map, however, which accompanies the paper does not include Jherria in the coal-field, and it is more than probable that the name was used by Mr. Jones, not as indicating the town of that name, but rather the property or 'raj,' which was the next adjoining to the country near the Barákur River, known to contain coal. Mr. Homfray, in 1842,* alluded to the extension of these coal-fields up the valley of the Damoodah, but entered into no details.

In the final Report of the "Coal Committee" dated 1845, in which a summary of all information previously collected was given, no mention of Jherria is made, nor do I find any further notice of it until in 1856, Mr. D. Smith, who had been sent to this country by the Hon'ble the Court of Directors of the East India Company, to enquire into the feasibility of working iron, briefly refers to this field in a "Report on the Coal and Iron Districts of Bengal."† He says, he stopped on his way to Palamow, at the "Fitcooree bungalow, to visit Jurrhiah, a mineral "district about 8 or 9 miles distant to the south. The indications here "are far from encouraging. The strata are very disturbed, with every "appearance of an unimportant deposit of ore." He evidently made a very hurried examination of the district, and does not even allude to

* Jour., Asiat. Soc., Bengal, Vol. XI, p. 723.

† In a pamphlet published by Government.

the occurrence of coal. The field was subsequently visited and examined by Dr. Emil Stöhr, a Swiss Mining Engineer of considerable experience and skill, on behalf of some colliery proprietors in Calcutta, but, of course, his results were not made public. In 1862 and following year, Major J. L. Sherwill, who was in charge of a party of the Revenue Survey engaged in mapping this district, brought the coal of the field to public notice, and continued to forward specimens and statements of localities. But he added nothing to our knowledge of the geological structure or even of the limits of the field.

Immediately on the topographical map of the district becoming available, Mr. Hughes was deputed to take up its examination in detail, and the result of his investigations is given in the preceding Report.

The sections in this field have been given with an amount of detail which would, as a general rule, be quite useless. I thought it desirable, however, to give all this detail, in one instance at least, in order to show the full character of the rocks of the lower part of the coal-bearing rocks of India, which are in this field well developed, and of which Mr. Hughes' carefully measured sections give a very good idea.

The general extent and value of the coal in the field is also shewn in considerable detail in Mr. Hughes' sections. And while it may be necessary to give a word of caution, as to the probability, nay almost certainty, that these beds of coal will not prove continuous, but will rather be found to diminish rapidly, and even to die out, within short distances, to such limited thicknesses as will render them unworkable with profit, it is at the same time beyond a question that a very large amount of good useful coal can be obtained from this field.

In attempting to estimate the value of any field, it must be remembered that this depends not so much on the actual amount of coal, which it may contain, as on the way in which that coal is accumulated, or the conditions under which the beds occur. Six seams, for example,

of one foot thick each, would contain twice as much coal as one seam of three feet, supposed to cover the same area. The latter, however, or the three-feet sea,m might probably be worked with profit, while it certainly would not pay to work seams of only one foot thick: I should perhaps more correctly say, to *mine* seams of one foot thick. If such seams were accessible in open cuttings or quarries, they might be profitably extracted. But further, the question of what seams can be worked with advantage, will depend for its solution on the dip, or angle of inclination of the beds; on the vicinity and extent of the demand, or market; and on the skill of the labour at command. And if the ruder labour which can be obtained in this country, as well as the absence of all those mechanical appliances which exist so abundantly in the long-established collieries of England and other countries, be taken into consideration, I think I am quite within the truth in asserting that no seam of coal can be mined in this country with any fair prospect of profit which is not at the least four feet in thickness.

I am aware that seams of even less thickness than two feet, the half of this, are worked in England, but these are not common cases. And it certainly would not be justifiable to take the experience of a highly civilized country like England, where everything is in favour of such operations, as a guide in estimating the practicability of working seams of coal in this country. There a local demand would be found to exist, in almost all places: there is a large, widely spread and skilled, mining population, and great facilities for securing and for raising the coal. And, in addition to all these points, there is the superior quality of the coal itself. It must be admitted that, on the average, Indian coals are not equal in value to average English coals. In few cases are they worth more than two-thirds of English coal, in some cases not more than one-half. In this way a seam of Indian coal of three feet thick, would only be the equivalent of one of 18 inches, or of two feet of English coal.

In the summary given at the end of Mr. Hughes' Report a statement of the amount of available coal is given, in the different sections in different parts of the field. These are so placed that for the purposes of a rough approximate calculation of the quantity of coal obtainable from this field, we may, I think, take as a fair average thickness of workable coal the mean of all these sections. This would give nearly 24 feet; and, if, making a large allowance for the imperfect data we have to deal with, we take this thickness at 20 feet, and suppose that this will extend over less than a third of the area of the field, say 60 square miles, we would have an available supply of coal amounting to about 465 millions of cubic yards, or, roughly, tons.

But every such estimate must be of the rudest kind possible, with reference to a coal-field, in which not a single pit has yet been sunk, nor a single opening made.

Whatever the margin of error may be, however, the facts are sufficient to prove the existence of a very large amount of good fuel in this Jherria Field, which at some future period will be found most valuable.

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Summary of Geological Observations during a visit to the Provinces— Rupshu, Karnag, South Ladak, Zanskar, Suroo *and* Dras—*of Western Tibet,* 1865, *by* F. Stoliczka, Ph. D., *Geological Survey of India.*

Introductory Remarks.

In the following notes I propose to record some of the principal facts, which have been noticed during a geological survey of the above-named districts or provinces of Western Tibet. As these notes are intended only as preparatory to a more detailed report on the geology of the N. W. Himalaya, the facts will not be stated in as strictly systematic a form as might be desirable, although they will come necessarily in connection with, and supplementary to, my "Sections across the N. W. Himalayas, &c."* I would also remark, that the statements here recorded cannot be considered as fully conclusive with

* Memoirs, Geological Survey of India, Vol. V, part 1. The present notes must be read in connexion with this previous paper. But for convenience it may be desirable to give here a Summary table of the several local groups or formations established in the Himalaya, and their approximate European equivalents.

Gneiss, metamorphic rocks, &c.

I. Palæozoic.

Bhabeh Series	... Lower Silurian.
Muth Series	... Upper Silurian.
Kuling Series	... Carboniferous.

regard to the geological structure of the country, because they have been derived from *local* evidence only. The want of a thorough or, at least, a sufficiently extensive examination prevents at present our bringing all this local evidence into such systematic connection, as would be required even for a rough geological sketch map. The object of giving publicity to these brief notes is solely to make those, who take an interest in the geology of the Himalayas, acquainted with the progress of the survey and with some additional discoveries as to the age of the different formations.

As I shall in the following pages have to refer to different localities of Western Tibet, I shall first point out the route, which I followed during my visit to the country in 1865.

Starting from Simla on the 1st of May 1865, I proceeded through *Suket, Mandi*, the *Kulu valley*, and then crossing the *Rotang pass*, to *Kyelang* in *Lahul*. Here I was detained for nearly a week, waiting until I could hear, whether the Baralatse pass was passable or not. After having received favorable reports, I managed to cross the pass on the 22nd June, and after two short marches reached the *Chumig-giarsa*, a spring remarkable for its large supply of cold water, a little north of the junction of the Lingti and Yunam rivers, and at the place where the Tsarap river unites with both. Up to this the course of my journey was, more or less, but mainly, due north from Simla.

II.	Secondary.	
	Lilang Series	... Triassic (upper).
	Para-limestone	... Rhætic.
	Lower Tagling limestone ...	... Lower Lias.
	Upper do. do. ...	... Middle Lias.
	Spiti shales	... Oolitic, middle.
	Ghiumal sandstone ...	... Oolitic, upper.
	Chikkim beds	... Cretaceous.
III.	Tertiary.	
	Indus or Shingo beds ...	... Nummulitic.
	River and lacustrine deposits.	

From *Chumig-giarsa* I turned towards the east, proceeding south along the *Tsarap* valley up its course; crossed the *Pangpo-la** into the *Phirse* valley, then the *Lanyer-la* into the *Gya* valley, and after a few minor passes (of about 18,000 feet in elevation) reached *Korzog* on the 2nd July.

Here, being at the principal camping-ground of the Rupshu tribe, I arranged for my farther journey, and started, on the 5th July, for *Puga*,† and from here towards the *Thso-kar*‡ and the foot of the *Taglang* pass, the second camping ground of the Rupshu tribe. After again one day's interruption of my journey, rendered necessary by making further arrangements, I crossed the *Taglang* pass and reached *Lei* on the 16th July. This place I left on the 21st July, proceeding towards the village Rumbag, and then in crossing a few minor passes to *Trantse-Sumdo*, the summer camping ground of the Karnag tribe; crossed the *Shapodog* and *Saiji-la* and reached *Padam*, on the 6th of August, after a horrible§ experience of hill travelling. Having seen the necessity of parting here with the remainder of my men from *Kulu*, who had offered me their services for the whole trip on my arrival in Simla on the 10th of May, a few days elapsed before other arrangements for the journey were settled. On 10th of August I was able to start, and proceeded from here to Suroo, and then to *Kargil*, from which a separate trip towards the Indus in a north-eastern direction (across the *Hambuling* pass) was thought necessary. I again left Kargil on the 1st of September; visited *Dras*, and reached *Sirinagur* on the 10th September; there I had

* *La* means a *pass* in Tibetan.

† *Puga* signifies a *hole*, referring here to the sulphur-mines.

‡ *Thso* means a *lake*; *chu* a *river*, or in general *water*.

§ I may remark here, that it is not the bad road or the high passes, which make travelling in these wild countries so exceedingly difficult at this time; in this case it was chiefly due to the large quantity of glacier water, which had swollen every stream to a depth of 3 to 4 feet; and to cross these torrents, often twenty times, while on a day's march, is ruin to those who cannot enjoy every comfort during and after the day's work.

to overcome some of the difficulties of the season, and of certain restrictive orders as to travelling in Kashmir, but I at last managed to start, on the 26th of September, on my route through *Islamabad, Kishtwar, Budrawar, Chamba,* and *Kangra,* and reached *Simla* again on the 31st of October 1865;—thus terminating my trip for this season.

In attempting to place upon record the scattered geological facts noticed in this journey, I think the best plan will be to describe the four principal sections across the country south of the Indus and north of the Baralatse range. These four sections are—

I.—Section from Kyelang, in Lahul, to Korzog, the principal camp of the *Rupshu* tribe, on the *Tsomoriri.* The direction of this section is from south-west to north-east.

II.—Section from Lei, or the Indus valley near Lei, to Padam, the principal place of the province of *Zanskar,* at the junction of the *Zanskar* and *Tsarap* rivers.

III.—Section from Suroo towards the Indus, north of Kargil.

IV.—Section from Kargil towards the Sind valley in Kashmir.

To these I shall add a few words on the probable connection of the secondary deposits, and on the great disturbances, which must have taken place in Western Tibet at the time of the different deposits.

CHAPTER I.

Section from LAHUL *to* KORZOG.—As I have observed in my "Himalayan Sections," the rocks of the Kulu valley proper are metamorphic, micaceous and gneissose schists. These rocks continue for a short distance after crossing the Rotang pass, but in South-Western Lahul they are overlaid by slates and thinly-bedded blue and yellowish limestones, stretching apparently farther towards south-west into Eastern-Kishtwar. I cannot approximately ascertain of what these rocks may be representatives, although they appear to be, at least to a great extent,

the same which Mr. Medlicott has pointed out as equivalent to his Krol series, in the south-eastern portions of Kulu. I almost believe that they are in connection with the silurian beds of North Lahul, as they correspond with them in their stratigraphical position, but I have not been able to trace this connection, which is partially interrupted by gneissose and other metamorphic rocks.

The 'central' gneiss of the Chandra valley is only of a few miles width in North Lahul, between the villages Kangsar and Daree, and higher up on both sides of the valley it is overlaid by undoubted silurian rocks.

The lower beds immediately above the gneiss agree in mineralogical characters with the rocks of the Bhabeh series, and a yellowish, light coloured limestone is seen to occupy the tops of the hills, forming nearly horizontal strata. In loose pieces of this limestone I found, west of the Baralatse pass, (near camp Zingzingbar), traces of *Trilobites* and *Orthis*, but I am unable to ascertain whether these limestones belong to the Bhabeh series proper, or whether they correspond with the middle limestone beds of the Muth series, that is, respectively of lower or upper silurian age. The former suggestion seems more probable.

Rocks of a similar description, being siliceous greenish sandstones, carbonaceous slates, whitish quartzites and thin-bedded limestones, continue across the Baralatse pass, until within about four miles of the mouth of the Lingti river. North of the Yunam lake the beds are partially metamorphic, and at the said boundary there is a mixture of sandstones, conglomerates, quartzites and limestones. Any one acquainted with the rocks of the Muth series in the Pin valley would find all these rocks here represented also, but the usual regular stratification is by no means clear. Very considerable disturbances must have taken place about the Yunam lake, which, no doubt, caused the appearance of metamorphic rocks to the north of it. On reaching the Lingti river, triassic limestones of the Lilang series are to be found abundantly, and

round Chumig-giarsa the hills are capped with Para-limestone; the former very much disturbed, the latter less so. Some of the most remarkable contortions of the strata are seen just above Chumig-giarsa. The Tsarap valley extending towards the east from the last named place, lies principally in Rhætic beds of the Para-limestone; only before reaching the camp Lama-Yuroo on one or two lateral streams true carboniferous rocks with *Productus semireticulatus*, and next above this Trias limestones with *Spirifer Stracheyi* are met with. The Para-limestone, of the usual bluish colour and dolomitic structure, is well characterized by the great abundance of the large bivalves, as *Dicerocardium Himalayense*, *Megalodon triqueter* and some others.

In the upper portion of the Tsarap valley all the higher hills on both sides, consist of lower Tagling limestone, occasionally with abundant *Terebratula gregaria* and *Rhynchonella Austriaca*. Reaching the foot of the Pangpo-la, a great quantity of debris of the Spiti shales and Ghiumal sandstones is visible, and these rocks are *in situ* at heights above 18,000 feet, flanking on both sides the Pangpo-la, which, although at an elevation of more than (or about) 18,000 feet, consists still of lower Tagling limestone. The presence of Spiti shales and of Ghiumal sandstones is undoubted, as I have seen fossils from both these series; and on the top of those hills, occupied by the two formations, cliffs of a white limestone are visible. I have seen merely fragments of this limestone, and I cannot, judging from my previous experience, attribute them to anything but to the *Chikkim limestone* of Spiti, being of cretaceous age. The continuation of the *cretaceous strata* is a prominent fact.

On the northern side of the Pangpo-la the Tagling limestone continues to remain the prevalent rock for some distance, followed for a short distance by Para-limestone, which appears to be more developed towards the south-east. From about the small lake Kyangshisa up to near the mouth of the Pangpo stream all is limestone, belonging chiefly to the Lilang

series. I am glad to say that my conjectures of last year as to this limestone in the Para valley have been thus confirmed, as I found here an unmistakable *Ammonites Batteni,* while last year I was not able to confirm my suppositions by the occurrence of any fossils. At the mouth of the Pangpo stream into the Phirse valley the slates can only belong to the Kuling series, being perfectly identical with the rocks of this in mineralogical characters and geological position, underlying the Lilang limestones. The range between the Phirse valley and the Thsomoriri near Korzog consists of metamorphic rocks, of which there are some gneissose beds traceable below the Lanyer-la. The same metamorphic rocks continue, as stated in my "Himalayan Sections," all the way into the Puga valley, and this season I traced them also all the way from Puga to the Thsokar, across the Taglang pass, up to the village Gya, where the rock assumes a great consistency, and is chiefly a massive gneiss with a large proportion of white quartz and occasionally diallage replacing the mica.

CHAPTER II.

Section from LEI *to* PADAM.—Already when observing rocks in the Indus valley, north of Gya, I have been very much struck with their more recent aspect, as compared with the same rocks (which undoubtedly they are) at the mouth of the Puga stream, examined during my survey of 1864. North of Gya they consisted of soft and partly loose conglomerate, reddish and purple slates and marls, and greenish sandstones, very much like those on the Dugshai hill and to the north of that station. I can attribute this comparatively recent aspect of the rocks north of Gya solely to the subordinate development of the Gabbro or Diallage rock, which in the Puga valley seems to have perfectly altered and metamorphosed the slates and sandstones. Although finding in the Indus valley round Lei everything consisting of granitic and syenitic rocks, the impression, which I received in seeing the sandstone beds north of Gya, was so much in favour of their comparatively

recent age, that I determined to examine these beds again to the south of the Indus, and with this view I started on the formidable road.

Near Lei the Indus valley separates the younger rocks on the left bank from the syenitic rocks on the right bank of the river; the former dipping chiefly to south-west, and being, farther to the south, very much contorted and disturbed. Mineralogically these rocks remain here almost unaltered, but there are all gradations, from the hardest siliceous to the soft marly sandstones, to be met with. At the village Rumbag, where the sandstone beds are greatly developed, I at last procured *Nummulites Ramondi* and *N. exponens,* and met with the same and other less distinct, but certainly *Nummulitic fossils,* towards and about the Shingo-la, on the road from Rumbag to Kew (Skew).

About one mile distant from the last named village and approaching the Marka and Zanskar valleys, the nummulitic rocks are suddenly replaced by slates and carbonaceous limestones full of Crinoid stems, which appear to be of Carboniferous age. All the way up from Kew to the head of the Marka valley, at the Zalung-karpo pass, nothing but these carbonaceous crumbling slates occur, and still I have not been able to procure even a trace of any well determinable fossil, nor was I successful in forming stratigraphical or mineralogical distinctions. I cannot at present throw out even a suggestion as to the real age of the entire complex group of these rocks, but I have been informed by a friend, that he met on the Jena station, (farther towards the east), bluish slates full of a kind of coral, which from his drawings and descriptions I could only compare with *Chæteetes Yak.* It is probable, that both silurian and carboniferous rocks are represented among these slates, and the boundary between them may be found better traceable in some other section.

Having crossed the Zalung-karpo pass from the Marka valley to South Karnag, a great number of limestone ranges present themselves to view. Below the ruins of the old monastery *Khar* I met *Ammonites Aussecanus*

and *Monotis salinaria*, thus proving the true existence of Triassic rocks, or of *Lilang* limestone. The beds of this are altogether not much above 1,000 feet thick, and are overlaid by bluish Para-limestone of a thickness of about 500 feet only.

The ridge, which separates here the Khar-chu and the Yelong-chu, rising up to about 19,000 feet, and of which Carboniferous, Triassic and Rhætic (Para-limestone) beds form the basis on both sides (in either valley respectively), consists, higher up, throughout of a whitish or pure white dolomitic limestone. I have not been able to trace any fossils in it, except minute Crinoid stems or rather only fragments, but I confess that I have never seen a rock more closely resembling the great masses of "Hauptdolomit" of the Alps than this, and as the stratigraphical position is not opposed to the idea of their being equivalent deposits, this rock can justly be looked on as being of the age of the upper Rhætic beds. All the way from Trantse-Sumdo to the foot of the Shapodog-la, Para-limestone is the principal rock, contorted and disturbed in every possible direction, and of enormous thickness, but always full of the characteristic *Dicerocardium*, *Megalodon*, and similar bivalves. Near the camping ground Lapurba I obtained in it a few Rhynchonellæ, somewhat like the larger varieties of *Rhynch. Austriaca*, but specifically distinct and apparently new.

At several places, chiefly at the junctions of lateral streams, the limestones are interrupted by slaty rocks, which are more probably Lilang slates, than belonging to the Kuling series. On the foot of Shapodog-la the Para-limestone is regularly underlaid by a concretionary limestone and sandy slates, which certainly can be only Triassic, and probably include some of the reddish and greenish slates of lower Triassic age. The ridge of the Shapodog-la itself is partly rhætic, partly liassic limestone; but I have not been able to ascertain either strictly. Circumstances totally prevented any correct observations being made. In the valley

west of the Shapodog-la at Niri-Sumdo true lower Tagling limestones are met with, and are at several places overlaid by Spiti shales. Whether any Ghiumal sandstones, or still higher beds exist, I was unable to ascertain. The Saiji-la is undoubtedly lower Tagling limestone, as I have obtained a good number of characteristic fossils towards and on the top of the pass itself. South of the pass the Tagling limestone continues, but in the distance above the deep valley, I believe I have observed Spiti shales. At the southern foot of the Saiji-la true Para-limestone is present, and is followed by triassic rocks, being slates and limestones. Fossils are not at all uncommon in the whole series of limestones, all the way from the Shapodog-la to the south-western declivities of the Saiji-la, and I for ever regret that the ruined state of my camp and the bad weather prevented me from paying proper attention to these interesting strata. The Zanskar valley is found to consist on both sides of triassic limestone, contorted in the most fantastic manner. It is of light blue colour, while the Rhætic limestone, being much darker, can be easily traced here and there on the top of a hill, or on the side where a piece of it has been caught in a contortion. About the village Thonde the Triassic beds are separated from the silurian sandstones by a dark band of a greenstone-like rock, which I presume to be carboniferous, although I do not possess any positive proof. The silurian rocks themselves extend to Padam, the Tsarap river forming the boundary between them and the gneiss towards the south-east. The Shingkun pass, on the road from Padam to Lahul, is, so far as I can see from specimens obtained by the Rev. Mr. Heyde, gneiss and metamorphic rock.

The Zanskar valley near, and north of, Padam is very broad, and the thickness of accumulated shingle deposits amounts in some places to several hundred feet, forming extensive plateaux, which are again in places considerably raised by accumulations from lateral streams.

Proceeding from Padam in western and northern direction silurian and metamorphic rocks are met with; the former especially down in the

valley, while the central ridge of the Baralatse range to the south consists (at least on its northern side) of the latter. North of Rangdum Goupa* a great thickness of secondary deposits, undoubtedly of different formations, is observable, but time did not admit of my crossing the country here, as I should like to have done.

CHAPTER III.

Section from SUROO *to the* INDUS, NORTH OF KARGIL.—The metamorphic rocks of the Baralatse range, south of Suroo, extend to the north of this place with an unchanged mineralogical character up to the village Zangra. Here they carry a large proportion of hornblende, and overlie a mass of gneiss in a dome-shaped bedding. The gneiss, which is very well exposed near the old fort Carpo-khar, consists of a great quantity of white quartz, orthoclase and muscovite; biotite being rather subordinate. On the northern side it is overlaid by a similar hornblendic shist, which gradually, somewhere near the village Sankoo, changes into talcose and chloritic shists, these being themselves followed towards the north by micaceous shists. From Sankoo to Saleskoot tough chloritic and quartzitic sandstones prevail, and to the north of the last named place they are in contact with syenitic rocks.

The banks of the Suroo river from here, until it joins the Indus, consist, with little interruption, of the same syenitic rock throughout. Although the formation does not represent any thing remarkably new, the mineralogical composition of the rock itself is extremely interesting, varying in every degree from a minute to a large micro-and macro-crystalline structure. Large crystals of hornblende and diallage, nests of epidote and serpentine, are by no means uncommon. The quartz is usually grey, the felspar milky white, partially certainly albite, or occasionally a fleshy orthoclase. The interruption, to which I just alluded, is formed by some tertiary beds in the neighbourhood of Kargil.

* *Goupa* is simply a *monastery*, and *Rangdum* is the name of the district.

They consist of sandstones, purplish slates, conglomerates, and greenish shales, on the whole identical with the similar rocks noticed south of Lei and north of Gya, and as described in detail by Mr. Medlicott from Subathu and Kasauli. I have not seen any fossils in these strata here, but Mr. Drew has obtained to the east of Kargil in some of the lowest beds a few Gastropoda, which are very like *Melania*, and bivalves, almost unmistakably belonging to *Pholadomya* or *Panopœa*. The fossils do not admit of an accurate specific determination, but having traced these rocks beyond the Hambuting-la for several miles, and seeing them to extend towards the Indus valley, I can scarcely believe, that they are anything else than the most western prolongation of the nummulitic rocks. I mean the most western, inasmuch as they are in this place perfectly cut off on the western side by the syenite, and I rather presume that these beds have been formed in a kind of narrow bay of the Tertiary sea, which covered Northern and Eastern Tibet. This local formation would also easily explain an admixture of fresh-water and marine fossils. But as I have had no opportunity as yet of seeing the south-eastern boundary of these rocks near Pashkium, I am unable to produce decisive proof for my suppositions. The total thickness of these probably nummulitic rocks amounts here to about 5,000 feet, if really so much as that; but I think it cannot be estimated higher.

CHAPTER IV.

Section from KARGIL *into* KASHMIR.—I have comparatively very little to say on this section, as it is taken close to and only a short distance to the west of the former. The syenitic rocks continue with unchanged character up to about half way between Tazgaon and Dras, and are followed here by the same dark hornblendic rock, which I have mentioned between Sankoo and Saleskoot (north of Suroo). The stratification of this rock, which I presume to be representative of the silurian, is generally very indistinct; it seems to extend far towards the

west and south-west into Kashmir. In the section, notified above, it is to be met with only a few miles south of Dras, here changing gradually into thinly stratified, first chloritic, then carbonaceous slates. These I believe to be carboniferous rocks, continuing as far as Pan-Dras (or Pran-dras). In neither of these rocks have I met with even a trace of a fossil.

About one mile south of Pan-Dras a great thickness of a light blue limestone appears, forming the banks of the Dras river on both sides. In these beds I have seen in great numbers only a small bivalve, which I believe scarcely different from *Megalodon columbella, Hörnes,* from the upper triassic Alpine limestone. Farther to the south darker dolomitic limestone overlies the former, apparently identical with the Para-limestone. Both these are, at least as to their mineralogical characters, in no way different from the same triassic and rhætic rocks towards the east. The Zoiji-la, which leads into Kashmir, consists of a light grey or brownish siliceous sandstone, with a marked bacillar structure, such as can be observed south of the Boileaugunj hill near Simla. I am inclined to think that these rocks are carboniferous; certainly they cannot be far from this age. In the Sinde valley of Kashmir these rocks are overlaid—neglecting several interruptions and alterations of strata—by limestones and carbonaceous slates, in which I procured, near the camp Tashvaz, an authentic *Ammonites Gerardi,* thus proving them to be of triassic age, corresponding with our Lilang series of the eastern portion of the north-west Himalaya. Approaching the Kashmir valley the basis of these limestones and slates forms again carbonaceous and partially light-brown coloured or chloritic slates, which are undoubtedly carboniferous. They are underlaid by a similar chloritic rock with very indistinct bedding, as I have noticed about and north of Dras, probably Silurian. The carboniferous rocks of the Kashmir valley towards Islamabad have been lately noticed by Capt. Godwin-Austen in the Quart. Jour. Geol. Soc. Lond.

vol. XXII. p. 29. Some of the lower beds, which Capt. Godwin-Austen indicates in his sections, belong to the series which I think to be of Silurian age. The carboniferous rocks are for the most part easily traceable by a large number of the common *Producti, Spirifer* and *Fenestellæ.*

I could add here a few notes on the section from Sirinagur to Simla, but in this still less variety appears. The carboniferous rocks of the Kashmir valley continue towards the south-east up to the top of the Marbal pass, on the western side of which I collected a good number of characteristic fossils as *Productus semireticulatus, Spirifer Keilhavii, a Lima, Fenestella,* an *Athyris,* very like *Ath. Roissii* and others.

To the east of the Marbal pass only metamorphic rocks have been observed all the way to Chamba, from which place a ridge of gneiss joins with the rocks described by Mr. Medlicott in his Sub-Himalayan report, &c.* Some of these metamorphic rocks are probably altered silurian, but there is every reason to expect, that still older formations may be found in them, the rock deposits of which have been greatly metamorphosed.

Chapter V.

Remarks on the geographical distribution of the different formations and conclusions from the foregoing statements.

Viewing thus the results, which I obtained during my survey of 1865, they may be considered as of the highest importance for local evidence, but it is, as I have already mentioned, impossible to connect the sections with even approximate accuracy, so as to give a general view of the geological aspect of the country.

To arrive at such a general or complete view, it will be essential (at the least), to obtain a section from the Baralatse pass due north

* Memoirs, Geological Survey of India, Vol. III, Pt. 2.

towards the Indus; a second section from the Indus at Lama Yuroo to Padam, from north to south; a third section from Rangdum-Goupa again towards the Indus, and then to examine the country west towards Skardo, so as to be able to form an idea as to the western extensions of the syenite, and the carboniferous and nummulitic rocks, which Captain Godwin-Austen stated to exist somewhere in the neighbourhood of Skardo. This will fully occupy another season's work.

The few additions, which have been made during the past year to the facts stated in my "Geological Sections," &c., are as follow:—

(*a.*) The characteristic 'central gneiss,' (in so far as being traversed by veins of Albite Granite), is to be met with only very subordinate between Kangsar and Dareein North Lahul, being, on the whole, not more than a few miles in transversal diameter, and on the right bank of the river, only forming about one-half of the thickness of the steep, sometimes precipitous, slopes being overlaid by silurian rocks.

This would show, apparently, a gradual submersion of the central axis from south-east towards north-west, but it is not improbable, that the gneiss of the prolonged chain, south of Padam and Suroo, is the same as the central gneiss, only devoid of the Albite Granite veins, and these were probably rather the cause of its higher *emersion* towards the south-east than of a *submersion* towards the north-west. I have not crossed this chain anywhere, but it certainly disappears or alters its direction on the Zoiji-la, leading to Kashmir, and I am therefore unable to form an opinion on this subject.

(*b.*) The silurian rocks are of very great extent in North Lahul, being sandstones, quartzites and limestones of the usual character of the Bhabeh and Muth series. West towards Padam, Suroo, Dras, and Kashmir, the silurian rocks are principally chloritic, coarsely-bedded sandstones, occasionally passing into carbonaceous slates. South of the Indus, between Kargil and the Zanskar river, the slates seem to be prevalent,

and they probably extend, towards the Jena Station, into North and Central Rupshu, where, at least, the lowest beds of the same appear to be represented by metamorphic schists.

(*c.*) The carboniferous rocks are, if devoid of fossils, as is often the case, (unless met towards the middle of the geographical extent of the palæozoic and secondary deposits), very difficult to be traced, as I have already described in my "Sections across the N. W. Himalaya, &c." Referring to the section near Muth, as far as I can see now, I believe that the carboniferous deposits here seem to close a grand geological epoch, and that in the main their deposits filled only the interior of a large basin, which gradually and partially became dry land. The carboniferous rocks now appear sparingly dispersed in consequence of undulating contortions of the entire ground. Towards the west, especially in Kashmir and Little Tibet, the carboniferous rocks are, however, much more developed.

(*d.*) The Lilang series is well characterized all along the northern side of the supposed central axis, and the gneiss of North Rupshu and Karnag. The ***Monotis salinaria*** is an important addition to the list of the triassic fossils in this portion of the North-West Himalaya.

(*e.*) In immediate connection with the former deposits are the Rhætic beds or the Para-limestone. They are throughout easily traceable, wherever the former occur, generally topping the hills of the *Lilang* rocks and partaking to a great extent in the contortions of the same.

I may here again repeat, that the examinations of last year speak equally in favour of the Rhætic beds as restricted in my former notes, that is, beds with ***Megalodon triqueter, Dicerocardium Himalayense,*** and other fossils, belonging to the Trias-group, an opinion also held by French and Italian Geologists.

After the close of the Triassic group in the North-West Himalaya great disturbances must have taken place; large tracts of the country

were raised, and never more covered by the sea, until partially in comparatively recent periods (Eocene), while in other places the regular succession of deposits took place. One of these places was evidently the large northern *Jurassic basin* of the Himalayas, which I have partially described last year in Spiti and South Rupshu.

(f.) The lowest beds of this basin, so far as at present known, are considered the *lower Tagling* limestone, corresponding in age with the strata of Kössen, or the beds with *Terebratula gregaria, Rhynchonella Austriaca,* and others. I have traced these beds all through Southern Rupshu, Southern Karnag, and Central Zanskar. They are geographically the most extensive, and are usually overlaid by

(g.) Spiti shales, which are, or rather more probably have been, locally interrupted by superficial erosions;

(h.) The Ghiumal sandstones; and

(i.) The cretaceous Chikkim limestones, which have been seen only in the neighbourhood of the Pango-la, in Southern Rupshu.

The jurassic basin, which is so well developed in Spiti, and extends to North Kumaon, continues to retain the same north-western direction, with all the characteristic rock formations, until it becomes interrupted by the great granitic and syenitic mass of Little Tibet. A partial interruption seems to have taken place after the close of the Rhætic deposits; but whether the jurassic basin has been actually and totally interrupted here (that is, south of the Indus), or whether it has been only compelled to continue with its course towards the north or north-west in Gilgit and beyond the Mustag range, subsequent inquiries must prove.

(k.) A valuable addition to the knowledge of Himalayan Geology is the determination of the age of the rocks in the Indus valley, the same rocks, which I had supposed to be older; they are, however, certainly

nummulitic, and the specimens of nummulites, which Dr. Thomson brought down from the Shingo-la many years past, are from these deposits. Their geographical extent is up to the present time known only in the Indus valley from the mouth of the Zanskar river up towards Hanle.

As to their southern boundary they do not seem to trespass very much on the slopes of the southern or left banks of the Indus, but who can determine their northern and eastern extension? They certainly extend towards the Korakoram range, and the Korakoram pass, I am told, consists chiefly of similar rocks, as also the high land in Changchemno and the Kuenluen range. To trace the extent of these rocks towards the east, and to study their relations as to the younger tertiary mostly lacustrine deposits of those high plateaux, (*vide* Strachey's account of the Mansarovara lake), will be, in other words, to explore Central Asia, a very difficult, but a highly interesting task, which, no doubt, many would desire to undertake. A traveller could probably, without very much interruption, trace on this route a connection of these rocks with the nummulitic deposits of Japan, where they have been noticed by Baron F. Richthofen.

CALCUTTA,
29th March 1866.